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Science Translation For Non-Point Source Pollution Control – A Cultural Models Approach With Municipal Officials: A Final Report Submitted To The NOAA/UNH Cooperative Institute For Coastal And Estuarine Environmental Technology (CICEET)

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Submitted by

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Introduction

Part I. Understanding the Role of Culture in Science Translation

Across the United States, municipal officials, environmental management agencies and the public are making land use decisions that affect coastal waters. Local land use practices and development contribute to coastal habitat degradation from non-point source pollution caused by sediment, nutrients, toxins and microbial contaminants. Knowledge of the effects and consequences of land use decisions varies and is a critical aspect of effective ecosystem management.

A suite of factors influences knowledge about the relationship between land use decisions and water quality. Different levels of professional expertise, formal training and education, and local knowledge accumulated through direct relationships with places and water resources contribute to this knowledge. Knowledge interacts with values and attitudes to influence actions taken to address local land use impacts on water quality. Actions to protect water through land use occur within a complex social environment involving governance, business, regulation and citizen advocacy. This social environment is culturally distinct from the social environment of science and technology.

This is a tumultuous time for water policy in many coastal regions. Home rule in the northeast intensifies the important role of municipal government in policies affecting land use and water. Many groups focus attention on municipalities and local governments in an effort to foster the incorporation of ecosystem management principles into decision-making and policy. Scientists, technology developers, regulators and environmental NGOs have information and prescriptions for effective local action. Municipal officials can feel bombarded by these prescriptions when they are added to the already overwhelming task of "running their towns."

The pathway that science and technology must travel to reach people with the power and ability to take actions that influence environmental outcomes is fraught with cultural barriers. Local decision makers are eager to apply lessons learned from scientific research and technology development to the protection and improvement of coastal water quality. They are frustrated when that science and technology doesn't reach them or when it reaches them in a form they cannot put to use. Understanding the knowledge, values and beliefs of people working at the municipal level can facilitate science translation and technology transfer that is directly linked to actions that improve environmental outcomes.

Developing a cultural understanding of the knowledge, values and attitudes toward water management held by the people involved in municipal water management was the objective of this research. Focusing on a rural but rapidly developing region of the Gulf of Maine watershed, this project examined the cultural models of water, related to non point source pollution (NPS), used by municipal decision makers to make land use decisions with consequences for coastal water quality and the condition of coastal environments. This project developed an innovative approach to science translation by

bringing traditional methods from anthropology to the practice of ecosystem management at the watershed scale. By focusing research attention on cultural barriers to science translation, this project discovered areas of shared values that can be important bridges for knowledge transfer. This research also characterizes areas were values conflict, an equally important factor in the design of technology transfer and science translation.

A number of coastal management professionals will be interested in this project. Research, education and training about the causes of and solutions for coastal NPS pollution, and techniques of sustainable watershed management are primary focus areas for the National Estuarine Research Reserve System (NERRS), Sea Grant (SG), National Estuary Programs (NEP), the Cooperative Institute of Coastal and Estuarine Environmental Technology (CICEET), and state Coastal Programs (CP). This project was designed to provide those professionals with information and tools about the role that cultural understanding plays in the design, implementation and evaluation of education programs. Regulators, managers and education specialists working to implement the provisions of the Clean Water Act will find the results useful for designing public education and outreach strategies under the new Stormwater Phase II provisions of the act[1].

The critical importance of applying a watershed management approach in the context of ecosystem-based management was a key finding of both the Pew Commission's Ocean Report (2003) and the US Commission on Ocean Policy Report (2004). The municipal focus of this project is linked with ecosystem management efforts at the national scale. Within the focus area of this study are two NEPs, a National Wildlife Refuge, two NERRs and a flagship land protection project of The Nature Conservancy[2].

Scientists, practitioners and managers working across these organizations and programs work to generate information, establish knowledge networks to transfer that information and evaluate the outcomes of their programs. Understanding the internal and external culture within which environmental programs are conceived, implemented and evaluated is crucial to effective ecosystem management.

This project was embedded in The Coastal Training Program (CTP) of the Wells National Estuarine Research Reserve in southern Maine. Born from the Coastal Zone Management Act of 1972, the NERRS is a unique collection of marine protected areas created by federal, state and community partnerships that integrate environmental monitoring and research with a comprehensive program of education and outreach. Information on estuarine trends and conditions generated by the Reserves is used to support local and regional resource management and decision-making (Kennish, 2003).

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[1] Professionals working in these programs may be curious about the absence or minimal use of familiar terms like non-point source pollution, TMDLs, eutrophication and hypoxia from this report. This report contains perceptions about these issues in the language of the people whose actions at the municipal level influence environmental outcomes associated with these terms.

[2] Casco Bay Estuary Partnership, Portland, Maine; New Hampshire Estuary Project, Portsmouth New Hampshire; Great Bay NERR, Portsmouth, NH; Wells, NERR, Wells, ME and The Mount Agamenticus to the Sea Initiative of The Nature Conservancy based in York, ME.

Twenty-six NERRS sites, representing distinct coastal biogeographical regions of the United States, encompass more than a million hectares of estuarine, wetland and upland habitats. The Reserves are used as demonstration sites for long-term research and monitoring, resource management and habitat restoration (Kennish, 2003). Education and outreach programs encompass traditional K-12 environmental education programs, teacher training, public interpretive programs, and community education. The newly created CTP expands the scope and scale of education in the NERRS to include technical training and information transfer to coastal management professionals (Cook, et. al., 2002). CTP addresses one of the strategic goals of the NERRS – "to improve coastal decision making by generating and transferring knowledge about coastal ecosystems" (NOAA, 2003).

Prior to the initiation of the CTP, the communication of science and environmental monitoring information generated by the Reserves was a traditional and well-instituted practice. Coastal decision maker workshops focusing on locally relevant topics were part of Reserve education programs (Kennish, 2003). The CTP formalized this approach by requiring each Reserve to conduct a formal market analysis and needs assessment for each location. Training would be designed to address identified audience needs in ways that did not overlap with existing programs.

The Market Analysis and Needs Assessment for the Wells NERR CTP surveyed over 130 local, regional and state decision makers (Krum & Feurt, 2002). The results of this research identified municipal officials as the primary target audience for the Wells NERR CTP and ranked "water pollution, runoff and water quality" as a priority coastal management issue. Translating scientific information about water pollution and watershed management to municipal and local officials emerged as the focus for training.

The Coastal Training Program for the Wells NERR is unique in applying cultural models research methodology to the design and implementation of the program. The decision to use cultural models methodology was based upon a literature review supporting the proposition that translation of scientific information about NPS pollution to municipal decision makers could be more effective if it is informed by a cultural understanding of decision maker knowledge, beliefs and attitudes. An understanding of the cultural models literature is critical to understanding the ways this type of research can be applied to ecosystem management. A synthesis of that literature review appears in Part II below. A "Cultural Models Primer" was developed as part of this project[3].

Part II. What are cultural models?

Each of the seven propositions in the box below is a cognitive key that unlocks doors leading to complex mental libraries where ideas, attitudes, values and perceptions are organized. Psychologists and educational theorists call these units in our mental libraries *mental models* (Collins & Gentner,1987). Mental models function like maps, templates and field guides as we move through the world, allowing us to *unconsciously* recognize

[3] The Cultural Models Primer is available on the CICEET website, through the Project Explorer at http://ciceet.unh.edu/.

the familiar, categorize without thinking and link novel experiences to what we already know. Our mental models allow us to recognize a borzoi as a dog the first time we see one. When we order lunch, eat and pay the check in a restaurant we draw from script-like mental models that guide and constrain our behavior.

Cultural Models of Water

Water is the basis for life on earth. Water and land in a natural state, linked as a watershed, function as a water purification and storage system. Water is an economically valuable resource used by society to create energy, grow food and as a tool to shape the environment. Water is a commodity, harvested wild, processed, bottled and sold on the world's markets. Water is landscape, a backdrop for homes and businesses, inspiration for art and poetry, and places for snowboarding, rafting, and swimming. Water is waste, a convenient receptacle for carrying away and diluting unwanted products of society.

(Excerpt from Results beginning on p. 12)

Anthropologists are interested in the ways mental models are learned and transformed within a social group to become shared cultural models. Cultural models are taken for granted, and implicit within the social groups where they are shared (Holland & Quinn, 1987). They are used without "thinking" causing us to pay attention to select aspects of our surroundings, recognize objects and patterns, and assign meaning to our experiences. Cultural models have motivational force and guide our behavior (D'Andrade, 1995). As one of the cognitive tools in our problem solving toolbox, cultural models of environmental issues have been the focus of increased research attention for more than a decade (Kempton, et al., 1995.)

Environmental conflicts can arise from cultural differences associated with values, beliefs and knowledge. An understanding of conflicts arising from different cultural models can be used to improve dialogue. Science represents only one *way of knowing* about environmental issues. Research has shown that the cultural models of nature held by farmers and watermen demonstrate an understanding of the resilient and chaotic attributes of nature in line with modern complexity theory. Perspectives of these people who are in daily contact with nature are unique and valuable for collaborative learning applied in the context of co-management of natural resources (Paolisso and Maloney, 2000; Paolisso and Chambers, 2001; Paolisso, 2002).

Cultural models research has examined the complex interaction of attitudes, values, and modes of understanding surrounding an array of environmental issues including global climate change (Kempton 1991 a & b, 1993, 1997); protected areas management (Pfeffer, et al., 2001); and landscape conservation (Dailey, 1999). This research has the broad goal of understanding how humans make sense of and understand environmental issues and how this understanding is translated into decision-making and action. Applying an understanding of conflicting cultural models to participatory and collaborative processes can improve dialogue among stakeholders and create policies and environmental

solutions that benefit from a combination of different kinds of knowledge (Bunting-Howarth, 2001; Paolisso, 2002). Research techniques, including interviews, transcription and coding of discourse, and participant observation are used to make explicit the divergent cultural models that contribute to conflict among stakeholder groups (Bernard, 1998).

Coastal and estuarine related cultural models research has been used to determine: perceptions of effective coastal planning (Christel, et al., 2001); stakeholder and public perceptions of toxic dinoflagellate blooms (Falk et al., 2000; Paolisso & Chambers, 2001; Kempton & Falk, 2000; Paolisso & Maloney, 2000); farmer's understanding of nutrient enrichment in the Chesapeake Bay (Paolisso & Maloney, 2000), and perceptions of watermen about the role of science and regulation in management of the Chesapeake Bay blue crab fishery (Paolisso, 2002). Understanding the cultural models used by the lay public has helped scientists and resource managers communicate with important stakeholder groups, and has facilitated collaborative learning and public participation in decision-making related to nutrient management plans for coastal bays (Bunting-Howarth, 2001) and management of the blue crab fishery in Chesapeake Bay (Paolisso, 2002).

Objectives

This project tested and evaluated the application of cultural models methodology to facilitate the translation of science and technology to audiences able to apply that knowledge to protect and improve the quality of coastal waters. This project was the first part of dissertation research combining cultural models methodology and the Collaborative Learning approach of Daniels and Walker (2001) to improve coastal watershed management. The Collaborative Learning portion of this project is part of a 2006-2007 CICEET Technology Transfer project.

This project has three primary objectives.

1. To determine the cultural models used by municipal decision makers to understand the hydrologic cycle, stormwater impacts on coastal environments, connections between land use and water quality, and the role of scientific information in the decision making process.
2. To apply cultural models research methodology in the context of a NERRS Coastal Training Program (CTP), in order to determine if cultural models methodology can be an effective tool for the design and evaluation of education and outreach strategies.
3. To consult with other NERRS CTP Coordinators about the applicability of cultural models methodology in other regions and to develop a *Cultural Models Primer* for CTP Coordinators and other coastal outreach professionals.

Methods

Cultural models methodology is an evolving eclectic collection of traditional and novel approaches to anthropology (Quinn, 2005). The methods developed for this project followed techniques used by Dr. Willett Kempton and Dr. Michael Paolisso described in the peer reviewed literature cited above. Both Dr. Kempton and Dr. Paolisso served as project advisors providing input and feedback on data collection and analysis.

Application and evaluation of cultural models methodology to training design was innovative and the primary objective of this project. This methods section provides a detailed description of the methods used to discover and describe cultural models. These methods are traditional and broadly applied by anthropologists (Bernard, 1998). Evaluating the transferability of these methods for use by natural scientists working in ecosystem management were secondary objectives[4].

Evaluating Method Transferability

This project was part of the development, implementation and evaluation of the Coastal Training Program (CTP) at the Wells National Estuarine Research Reserve in southern Maine. The project was designed to address coastal management needs identified by the Wells NERR Market Analysis and Needs Assessment Report (Krum and Feurt, 2002) by focusing on the system of municipal water management in a rapidly developing coastal region within the Gulf of Maine watershed.

The principal investigator for this research is the Coastal Training Program Coordinator for the Wells NERR. The principal investigator is also a PhD candidate using the opportunity provided by the dissertation process to combine research and practice within a newly evolving national program for coastal training. During the two years of the project, the principal investigator presented project updates and solicited feedback from Coastal Training Program Coordinators and other professionals in the NERRS at Annual and Education Sector meetings. The principal investigator also served on the NERRS Strategic Committee and the CTP Performance Measures Workgroup during the course of this project. The Strategic Committee is part of the NERRS integrated decision-making process for the system. The principal investigator worked with the Strategic Committee to revise the NERRS Strategic Plan during the summer of 2005.

The system-wide perspective gained from over two hundred hours of participant observation provided consistent powerful feedback on the applicability, relevance and barriers to applying cultural models methodology to the Coastal Training Program. NERRS CTP Coordinators are the primary end users for the knowledge gained from this project. Analysis and deliberation about challenges for coastal training and science translation contributed to the development of conceptual framework for incorporating cultural knowledge into adaptive management strategies. This framework reflects a rich

[4] The principal investigator is an ecologist by education and training with a bachelor's degree in Zoology and a master's degree in Biology and 30 years experience in natural resources management. The dissertation research for this project is part of an interdisciplinary doctoral program in Environmental Studies

understanding of the mission and practices of the NERRS gained through participation in system-wide program planning and evaluation.

Determining Cultural Models of Water

The primary objective of this project was to investigate how people involved in water management at the municipal level use their knowledge of water in the environment to construct cultural models of water management and pollution. The cultural setting that delineates the boundaries of this inquiry includes scientists, regulators, policy makers, education and outreach professionals, developers and municipal officials.

What links the groups in this study is the relationship of their actions to conditions of water quality, land use practices and management of water resources in the coastal zone. Knowledge about water is differentially distributed among the members of this group and is characterized by varying levels of expertise. These groups operate under a variety of mandates and missions at the national, state and local level. That these groups share a common goal of protecting and improving water quality is frequently unacknowledged.

Language provides the analytical evidence for cultural models (Quinn, 2005). The cultural models methodology used in this project was open-ended interviewing that encouraged interviewees to explain answers to questions in their own words. What people say, the words they choose and, to some degree, what they leave unsaid, provides evidence of underlying cultural models as well as indications of knowledge about and attitudes toward water.

Twenty interviewees were selected to represent diverse perspectives on water. The goal in selecting interviewees was to capture a wide range of beliefs, attitudes and knowledge about water management in southern Maine. The interviews represent samples of the total discourse about water analogous to the way a meter square of salt marsh is analyzed as a sample of a larger ecosystem. In contrast to survey research design where variability can be problematic, cultural models research aims to understand knowledge that is shared and the range of variation within social groups. One strength of the data set for this project was the diversity of water management roles captured by the interviews.

Five of the interviewees were professionals working at the state or regional level in programs related to water. Fifteen municipal interviewees were drawn from three southern Maine towns with distinctly different demographics. The initial study design referred to the five regional and state level water managers as experts. As municipal interviews were conducted it became apparent to the principal investigator that each person interviewed possessed expertise as a water manager. The relationship of this expertise within the system of municipal water management became one of the most useful results from this project related to training design.

Three towns in southern Maine were chosen for this project. Two of the towns are in the watershed of the Wells NERR and have participated in water related projects with the NERR. The third town had less association with the NERR and was chosen to capture a different demographic and economic base.

Town Managers from each of the three towns chosen for this study were interviewed and asked to recommend additional people whose work at the municipal level was closely linked with water. A summary of the demographics of the towns and of the roles of people interviewed appears in Appendices I & II. Town names and interviewee names have been changed to insure anonymity[5].

Twenty open-ended interviews were conducted, tape-recorded and transcribed during the period from May 2003 - September 2004. Each interview lasted from 45 minutes to two hours. The total time spent interviewing was 32 hours. Three questions were posed to each interviewee.

1. Why is water important?
2. What are threats to water?
3. What can be done to protect water?

A list of probing questions was used to clarify meanings, promote detailed responses and identify common themes among the interviews (Weiss, 1994; Hammersley & Atkinson, 1995). The interviews produced over 300 pages of transcripts. A copy of the interview guide appears in Appendix III.

The data in these transcripts contained the building blocks of the cultural models used by the interviewees to reason about water and water management. The analysis of the interview texts to develop the cultural models applied the constant comparison method of grounded theory. Grounded theory is an inductive, theory building methodology applied to qualitative research (Glaser and Strauss, 1967; Strauss and Corbin, 1990)[6]. A key aspect of grounded theory analysis is the integration of data collection and data analysis. By using this iterative approach, the analysis of each interview provides insight into the structure of the cultural models. Those concepts can be added to subsequent interviews to verify whether an idea or concept is shared.

The grounded theory technique of analyzing the interviews for patterns, themes and concepts is called coding. Coding interviews "to saturation," the point where no new categories emerge, enhances the accuracy of the analysis. Codebooks were developed to document this analytical process.

Analytic attention to the use of key words, propositions, metaphor and reasoning are the cultural analysis tools used to "mine the implicit meaning" from the interviewees talk about water (Quinn, 2005 p.7). Examples of these cultural analysis tools using data from the interviews appear in Table 1.

[5] Protocols for interviewing human subjects followed established Institutional Review Board (IRB) protocols of Antioch New England Graduate School. When interview excerpts refer to specific places, those names were changed to protect anonymity.

[6] Although Grounded Theory may be new to many environmental researchers it is an established method in practice in qualitative social science research for almost 40 years. Interested readers are referred to the literature cited here for further explanation of the method.

Table 1. Cultural analysis tools used to code interview transcripts.

Cultural Analysis Tools	Examples from the Interviews
Key words	Clean water Drinking water Development Pollution Regulations
Propositions	Existing regulations do an adequate job of protecting water. It is the responsibility of municipal water districts to supply water and accommodate increases in demand associated with growth. People take it for granted that they will be able to turn on the faucet and get clean water. Vegetated buffers protect water quality by slowing down water runoff that may be carrying sediment and pollutants.
Metaphor	Wetlands are filters. Clean water is good business. Water is life.
Reasoning	*"… inherent in the Conservation Commission, I think, is that you have idealists, and I respect that. I'm stuck where the idealists meet the road … And I'm the guy in the middle. This position is one where you're always dealing with that conflict and you're that first contact in the codes office of telling somebody why they can't use their land."*

All interviews were coded initially for references to the three primary themes of the research - the importance of water, threats to water, and ways to protect water. Each primary theme was then coded for patterns that revealed the structure and relationships among ideas, concepts embedded in the primary theme. Features of Microsoft Word were used to create codebooks, segregate primary and secondary themes and organize the data into layered windows for analysis.

Analysis of each of the three primary themes produced three different types of results that will be presented in detail in the Results section. The differences in the structure of the results are summarized here.

The *narrative statements,* reflecting the six cultural models of water, in the box on page 3, were developed from coding the importance of water data. Coding and analysis of the patterns and themes in the interviews was used to develop a title or one sentence proposition for each of the cultural models of water. A short paragraph describes each model and a supporting narrative explains the models and provides examples of representative passages from the interviews that illustrate the meaning of the models.

In the case of threats to water, six concepts fit together into a cultural model displayed as a *causal sequence.* The component parts of that causal sequence are:

- Categories of threats - biological, chemical, physical
- Threats emanate from a source - places, institutions, practices
- Threats Move-pathways and transport mechanisms

- Threats affect a Target-places, services, target changes
- Losses Resulting from Threats-links to importance
- Root Causes of Threats-institutional, human behavior

The protecting water data produced revealed the structure and content of a *knowledge system* used for reasoning about water. This data is presented as a description of the different types of expertise and knowledge used to protect water. Differences in problem orientation, information seeking behavior and relationship to science and technology are attributes of this kaleidoscope of expertise.

Project advisors Dr. Tom Webler, Dr. Willett Kempton, and Dr. Michael Paolisso participated in the development of the interview protocols and evaluation of the coding strategy and data analysis. As part of the research team for this project, they provided on-going oversight of the design, execution and evaluation of the project. The principal investigator acknowledges their contribution to this project, but accepts full responsibility for the final interpretation and presentation of results.

Results

Results are presented in three parts:

Part I. Cultural models of water
Part II. Perceptions of Threats to Water -A Cultural Model of Risk and Loss
Part III. A Knowledge System for Water Management in Southern Maine

I. Cultural Models of Water

> *The value of water? Do I have to hit the obvious things like, we all need it to live and drink and survive…?* *Bernice, Town Planner*

> *We need water to sustain life, obviously, and it needs to be clean water. It can't be contaminated water, obviously. But it goes way beyond that. It goes beyond cleaning ourselves, cleaning our homes, cleaning our vehicles… It's a major, major necessity of life. It really is. And everybody uses water every day. Everyday we use water so we have to protect our resources. Obviously.* *Van, Citizen Chairman of Planning Board*[7]

The municipal officials, water managers and scientists interviewed unanimously acknowledged the importance of clean water. Fundamentally, water is the source of life. Water's economic importance was recognized in tandem with its spiritual importance. People discussed water in places, experiences with water, using water, managing water, harvesting water, threats to water, protecting water and polluting water.

[7] Excerpts from interview transcripts appear indented in italics. Names of interviewees have been changed to protect anonymity. Demographics of the towns included in the interviews and the role of interviewees in water management appear in Appendix I & II.

Six cultural models related to the value and importance of water emerged from the analysis of interview transcripts. The title of each model is presented as a propositional statement. The title and a brief synopsis of each model are highlighted in text boxes below. A narrative that describes the key features of each model with representative quotes from the interviews appears after each box. The representative quotes are selected from the series of quotes used to identify patterns and develop codebooks. They are chosen as the most illustrative example for each model.

1. Water is the basis for life on earth.

Water is the basis of life on earth. Water is essential to humans, animals, plants and all living things. The biological, chemical and physical characteristics of water affect life from cells to ecosystems to global climate. Human health depends upon clean water.

The first responses by interviewees to the question, "Why is water important?" reflect the essence of this cultural model as knowing that water is essential, foundational and integral to all life. This knowledge of clean water's value is implicit - out of awareness but easily brought to the surface (Strauss and Quinn, 1997).

> *I think everybody has probably a different perception of water. Some people just take it for granted that they turn on the faucet and it's gonna be there. Right? Most people probably do think that. But, if they never had water or had problems with water they'd probably think differently. … People need to be aware that water is a valuable resource… for our lifestyle… we need it for our lives, to live. If we abuse it, we'll lose it.*
>
> *You don't want to even take a bath in dirty water, obviously. But some people probably don't have the choice. Look at the foreign countries. You see it in the papers all the time, you know, these countries have sewer running right down next to their houses and… You know, that's sad. It really is. And then that creates all these other diseases. One gets the other. And we need to keep it clean for our own health. If you don't have it, you notice it.*
>
> *Van, Citizen Member and Chairman of Planning Board*

> *Well, obviously it's important for sustaining life.*
>
> *Ward, Town Planner*

> *It supports life. Water makes you grow, and animals and everything, so water is very important. It's one of the basics… basis of life.*
>
> *Spencer, Conservation Commissioner*

Each of the four municipal officials quoted above and at the beginning of this section acknowledged the *obvious* value of clean water as the basis for life. Van's comment also captures the *taken for granted* nature of our thinking about water. We turn on the tap and it's there. Yet, as Van is quick to point out, you don't have to look very far for situations where clean water is not taken for granted. For him, clean water and human health are closely linked. At the time of our interview, he drew examples to support his reasoning from developing countries. Following Hurricane Katrina in August of 2005, Americans had a new library of images to draw from. As Van says, "If you don't have it, you notice it."

The value of clean water is something that is taken for granted. Despite being taken for granted, there is awareness, upon reflection, that clean water is a finite resource. A watershed educator describes the way water quality is linked in his thinking to ecosystem health, wildlife and wildlife habitat, human health, economy and quality of life in communities.

> *"Water quality is important for wildlife and wildlife habitat… I think of them the same way I think of ecosystems and ecosystem health. The importance of ecosystem health and water quality, of course, is tied to those things, directly to the land use but also to the ecosystems – water ecosystems and habitats themselves…ecosystem health for me ties directly to human health and quality of life issues in our communities. There is an economic argument to be made for water quality and restricting waters critical for good healthy drinking water, critical for human populations - that's directly linked to water quality in surface water and open waters and our streams and rivers and everything else. Those three broad areas, ecosystems, human community health and economic health, all those things are linked to ecosystem viability. You can't separate one from the other."* *Mike, Watershed Educator*

For Mike, water is vital to an interconnected system involving organisms, the places they inhabit and the quality of those places. Humans and wildlife, human communities and wildlife habitat, quality of life, the economy and ecosystem health are all linked. Throughout Mike's interview, he wove a web of interconnection that emphasized his thinking about linkages between water, human health and ecosystem health.

A coastal ecologist with a PhD in natural resources management, who teaches Biology to university undergraduates, was the only interviewee to describe specifically some of the biological properties of water that make it the basis for life, at the cellular level,

> *In biology you talk about everything that water does for living organisms, from temperature stabilization of the body to just keeping us hydrated so that our cells can function. Its cohesive properties are so important. That's at the level that I first think of it. And then for other creatures it's the same.* *Mary, Coastal Ecologist*

As shown in the examples above, the essential nature of water - its interconnecting role between human and natural systems and its bridging of scales from the cell to the ecosystem contribute to the taken-for-grantedness when we have clean water and the stark realization of it's finite qualities when we don't.

The fundamental meaning of water is evident in every day language. Water metaphors *permeate* our language, providing evidence of the cultural importance of water and its often-unattended appearance in our discourse. The *well* of knowledge is a place we go in our minds - a source and container we can draw from. During the interview process, we talk to see what *surfaces*. Through interview probes we go *deeper* into the thinking of the interviewee. A skilled interviewer respects the *flow* of the conversation and tries not to *inundate* the interviewee with his or her own reflections.

The first question in an interview usually stirs up what is near the surface. This was true with the first question, "Why is water important?" and the number of responses that included the word *obvious* or *obviously.* The look of surprise, the raised eyebrow, the *"everybody knows that"* quality of body language and responses are clues that the interview has touched a cultural model. This concept that "Water is the basis for life" is cognitively, *right below the surface* and as such can be easily accessed for reasoning about water. Water's role in sustaining life is the first thing that "*comes up*" when questions about importance are asked.

2. Water and land in a natural state, linked as a watershed, function as a water purification and storage system.

Water and land are interconnected as part of a natural system. The hydrologic cycle, driven by the sun's energy and the pull of gravity, functions to produce, move, filter, store and clean water as a sustainable and renewable resource. Infiltration, filtering, buffering and other biophysical purification systems work to maintain the cycle. Plants, animals and microorganisms are part of and dependent upon this natural system. Humans benefit from the biofiltration services provided by this natural system.

This cultural model of water and land linked as a natural system providing ecological services represents one of the most important differences between the municipal officials for whom water was a peripheral part of their job and interviewees for whom water issues were the dominant responsibility of their job. This cultural model reflects the interviewees' ways of reasoning about the hydrologic cycle and the ecological functions of watersheds as places where biophysical purification systems filter, store and release water. The municipal interviewees for whom water was a peripheral responsibility included members of planning boards, code enforcement, town managers. While these interviewees used their own words to describe their knowledge about portions of this cultural model, it was not as salient for them as for those interviewees working as water program managers or scientists.

The six cultural models that emerged from the analysis of the interviews are interconnected. The relationship between cultural model #1 *Water is the basis for life on earth* and this cultural model is that cultural model #2 represents a science based understanding of chemical, physical and biological properties of water and the structure and function of the water cycle. In essence people who use cultural model #2 link land and water as an idealized system that produces clean water naturally. Human actions come into the picture from *outside* this system to reduce its ability to produce clean water.

The five interviewees chosen initially to provide an *expert* perspective on water referred to the hydrologic cycle, and provided specific examples to support reasoning about the ecological services provided by water. The quote that follows is a synthesis of a lengthy discussion by the Jack, the Coordinator of a State Coastal Non-point Program, regarding the structure and functions of a pristine watershed. In this idealized pristine watershed, human impacts are absent or negligible. For Jack this idealized pristine watershed serves as a reference watershed against which to measure changes resulting from human impacts.

> *In a natural system, a balanced system, the threats to water quality from wildlife aren't as prevalent. The most general threat to a natural system is humans. Think of a balanced system as a situation where you had a perfectly pristine watershed, and within that watershed you had no human impact. Maybe it's a national park that's actually…it's a wilderness area. There are no impacts from humans. I would think that even though there are wildlife inputs of fecal matter, which may potentially contaminate the water for a human, the system is in balance with itself. Everything is interdependent within that area. You may have ebbs and flows of wildlife populations that may at some point impact water quality, just because of the higher numbers of animals…deer may contribute a higher number of fecal materials in runoff to the area.*
>
> *Typically, you don't have runoff that would carry the fecals to water because you've got a system that absorbs the water. You've got trees and a duff layer and wetlands that are all in tact. In a natural system you're less likely to have sheet flow. Sheet flow is mostly associated with an area where maybe you've got a low grass area. It's pretty unlikely in a natural area you'll find sheet flow. In a sense, from a human perspective, you could go into a wilderness area and quite easily consume that water and not get sick because that is a completely intact watershed that is in balance. When you start to alter it by increasing human presence, even by a hiking trail or maybe there's a road nearby, what you do is start to condense the wildlife areas. You start to change the hydrologic cycle by altering the runoff. These factors will start to throw that system out of balance. You'll get concentrations of wildlife. You'll get runoff that will carry pollutants into the water. You'll start to alter water quality in areas that are closest to human activity. You may still want to fish in it, you may*

want to go swimming, but you may not want to drink it… Probably the first level that would be impacted would be human consumption and that's speaking just simply from a human perspective.

Jack, Coordinator of Coastal Non-point Program for State Agency

This cultural model includes water as a part of a natural cycle that is in balance in its wild state without humans. This natural cycle operates on land within a watershed where land and water are part of an interconnected system that includes the ocean and atmosphere. This marriage of land and water in a watershed provides an ecological service by operating to store, filter and release water. Water so clean, you might be able to drink from a stream.

Cathy, the Coordinator of a state level program called Non-point Education for Municipal Officials or NEMO, described the ability of land to process pollutants and produce clean water. Like Jack, Cathy talked about a natural system for producing clean water through the water cycle. She talked specifically about the ways land; plants and microorganisms process water pollutants.

"Pollution generated around a typical house can be processed by soil and plants. Bacteria breakdown some of the pollutants, plants take up some of the nutrients like nitrogen and phosphorus. Heavy metals are not as easily removed by these processes . . . open space allows infiltration and allows the natural systems to work . . . buffering is easy because it's kind of a low-tech, fairly low cost way to prevent water pollution and it's a pretty potent way to prevent water pollution because the water runs off, plants slow the water down; it's filtered into the land and the pollutants tend to be absorbed or broken down by the plants before they reach the water."

Cathy, Watershed Educator

Where Cathy's description portrays the land as preventing water pollution by filtering and trapping water pollutants, Mary traces the fate of pollutants through the wetland. Mary is a wetland ecologist with a PhD in Natural Resources Management. Her description of the buffering function of wetlands provides details on the input, pathways and fate of pollutants entering wetlands. Residential runoff consists of nitrogen, phosphorus, heavy metals, and pesticides. This is inputted from lawns adjacent to salt marshes or fresh water wetlands inadvertently or purposefully via storm drains. The pollutants can be stored long-term in peat to be released by exposure to air through physical processes such as sea level rise or storm erosion and subsequent oxidation. The pollutants can be transformed, as in the case of denitrifying bacteria releasing gaseous nitrogen into the atmosphere. The pollutants can be passed through the food chain through grazers and decomposers. Through these processes chemicals can be released back into the water cycle.

People talk about wetlands in particular, as places to use as "sewage treatment plants" and to an extent, I think that's fine, but whether it's heavy metals or nitrogen or whatever gets incorporated into the plant

material… it gets inputted and then it gets taken up. Eventually that stuff is gonna end up back in the water cycle some where because even if it's, you know, as I said… the peat, if stuff gets deposited it becomes part of the peat, that may stay there for several hundred years. But who knows, over time, what might happen with the ocean rising or lowering that may eventually… peat might get oxidized and stuff will be released. So there are some places where it could be stored on a pretty long-term basis but I guess I have a problem with people who say, "Oh, we'll build this wetlands," and then put all this stuff and then the wetland will trap it… because when those plants… if they have heavy metals, when they die and decompose it still goes into the food web. It doesn't get washed out into whatever area. If it's a fresh water wetland, creatures that come in and eat there and then carry it away. So, I guess in the big picture I feel like it's all just gonna keep cycling around out there. And hopefully there will be places where it can be deposited sort of on a long-term… I don't know enough about the rates of how all these things move but, … I really do think that a lot of it just keeps moving. It doesn't really sit.

Either directly by grazers feeding on the tissue or decomposers that then shred and ends up in bacteria which gets eaten by some other consumer so… or washed out in the water so that it's picked up by some plankton somewhere. But somehow it moves on. It doesn't just go to the wetland and then sort of disappear… unless… something like nitrate can get denitrified and make nitrogen gas and then it ends up in the atmosphere. So, now that I'm talking I'm realizing that it's not just burial; some of it can get transformed, especially for nitrogen… end up in the atmosphere. That could happen with nitrogen.

Mary, Coastal Wetland Ecologist (EO2 p9 - 10)

Jack explained the idea that nature purifies water through action by microorganisms and filter feeders with an example of oysters in the Chesapeake Bay. An important part of his narrative is the historical perspective of environmental change to the Bay after centuries of human impact.

You look at that process and there's a perfect example of human impacts. The 1500's, 1600's is when colonization really took place in Maryland and they start to extract the oysters like crazy coming to the area through the eighteenth century… Then in the nineteenth century and the twentieth century and the population of oysters went down and the human impacts went up. It quickly got to a point where the impacts to the water quality were so bad, the agricultural impacts were so bad they (the oysters) couldn't process the fines (sediment) that were coming through the system; they couldn't process the bacteria that was coming through the system…now you've got the situation this year you have huge pockets of no dissolved oxygen in the bay.

Jack, Coordinator of Coastal Non-point Program for State Agency

This story reinforces the cultural model of a pristine watershed functioning to clean and maintain water quality in the Chesapeake Bay until human impacts impair that function. Knowledge of baseline watershed conditions in an undisturbed watershed combined with water quality indicators creates for Cathy and Jack the image of ideal conditions, where nature is producing, storing and cleaning water.

3. Water is a resource for humans to use and manage.

Clean water is good business. Clean, abundant water is economically important for agriculture, residential, municipal, commercial and industrial use. Property values, tourism, seafood harvesting and farming are dependent upon clean water.

Gaining economic benefit from the use and management of water and the idea that clean water is good business are key elements of this cultural model. Interviewees focused on the economic values of water for resource based businesses such as agriculture, the seafood industry, and tourism. The effects of clean water and water as a landscape feature on the market value of properties for residential and commercial use were also identified as important.

Before becoming a Town Planner in Maine, Lee worked for a New Hampshire town where water recreation played a significant part in the region's economy.

> *And where I focused on Winnipesauke made me really realize as well, the tourist and economic opportunities that come from water resources, the amount of money that having clean water can bring to the state because of people vacationing. That's absolutely huge.*
>
> *Lee, Town Planner*

Water use on a local farm provides a counterpoint to the regional tourist economy described above. Yet, both examples illustrate the cultural model of water as a resource. Spencer is a Conservation Commissioner and former Selectman for his town. He is a farmer by profession. Spencer has been using and managing water on his 60-acre farm for over 40 years. The interview with Spencer included a driving/walking tour around the farm in addition to the more formal interview setting at the farmhouse kitchen table. During our tour, Spencer showed me the ways he manages and uses water for his home, farm and farm-based business. Spencer's knowledge of his land and the ways that water moved over, under and through the land allowed him to manage the water both from the standpoint of controlling erosion and keeping sediment out of streams, and having water available to use as a resource for irrigation and animal watering. His ideas for managing land to store and move water to accommodate the needs of his farm occasionally puts him in conflict with state regulators.

Well, I can't complain too much because usually the State, maybe because I've been here so long, the people involved have been very, very obliging to me. We got that pond… to enlarge it up above... It was in a wetland. Of course, at first when I asked about putting a pond in they said, "Well, why not put it on the higher ground? Why put it in the wetland?" And I said, "Because that's where the water is.

. . . we're using land. Man is part of the land and when man is part of the land, living on a piece of land - you have to manage it. It's not like a wilderness area that is untouched. We do things to land because we live on it and then that has impacts on the land.

But the thing is where I differ from most of the people around here, to do this these wetlands have to be managed. You don't just leave them to do everything on their own because, you know, man is already putting an input in it and once a man puts an input in it the man has to manage it.

. . . you need to do some drainage and you need to be able to manage this. And I think… people here… ecology has to be managed for man because man is in it. If there was no man here it'd be a different story. So now we have to decide what we want to do with it and how we want to manage it. I'm not against all the drainage and stuff. I think that it's needed to make it useful for people.

Spencer, Conservation Commissioner, former Selectman

Ward is a Town Manager whose comments explain the way the perceptions of water as clean or polluted affect the desirability of a community and its ability to attract economic development.

People move to a community, they look for if they develop on a lot or if they have a home and there's public water and… It also relates to therefore, the desirability of a community as a place to live and therefore you would have spin-offs on that economic development. It's a real basic, obviously, one of the more basic needs.

The environmental aspect, too, in that it's got a quality of life if you have water quality in which the people drive by and they see a nice wetland or whatever versus a swamp which is polluted…A detrimental effect to the health and it's detrimental to wildlife but also to the human health of people living near there and also to the impression one has about a community and that effects economic development, in attracting people to a place. *Ward, Town Planner*

These three excerpts illustrate some of the ways that the cultural model of *water is a resource for humans to use and manage* is linked to economic concerns across a

variety of scales. The ability to actively manage water on a farm is linked to the economic viability of that farm. Perception of water affects property values at a commercial scale with implication for municipal tax bases. Water quality has state level impacts through connections with tourism and recreation.

4. Water is a Commodity.

Drinking water is a public and private commodity. Water is collected from the wild, processed to meet regulatory requirements and sold to meet residential, commercial and industrial needs. Water as a commodity may be sold for profit or as a public utility. Clean water is important for public health and safety.

This cultural model of water captures critical concerns for municipal officials. Providing and protecting drinking water represents an important if not the most important *environmental* responsibility of municipalities. Unless there is a problem, water as commodity maintains a peripheral position in everyday municipal operations. The municipal water district is the exception to this, where water as a commodity is their core mission.

This cultural model of water captures the interviewees reasoning about sources of drinking water, and collection and processing of water in compliance with regulations to make it safe and attractive for human use. The public drinking water sources for people interviewed for this study are local: a brook that runs between two of the towns in the study and a river adjacent to the third town. Over fifty percent of the people in the three towns get their drinking water from private wells. Municipal responsibility for these private wells includes regulating land use and municipal operations, such as highway maintenance, to protect private wells.

Interviewees discussed their attitudes about having a local water source. Incipient conflict over groundwater came up during some of the interviews. At issue is ownership and use of groundwater and the tension between public water sources, individual private use of ground water and commercial exploitation of groundwater. Discussion of groundwater included the recognition that water moving under the ground is a communal resource that belongs to everyone.

Excerpts from four interviews will be used to illustrate the cultural model of *water is a commodity.* Issues of drinking water supply protection emerged as salient and powerful in all of the municipal interviews. Responsibility, accountability and trust associated with the quality of drinking water were key themes.

Because this cultural model of water captures critical concerns for local officials, this description will provide specific details that may be of use in the design of education, outreach and science translation.

Bart is a Town Manager. When asked about the importance of water, he began by talking about supplying water to the residents of the town. He refers to the local public water source as "our own watershed." Over fifty percent of the residents in his town depend upon private ground water wells. Although well owners are not *purchasing* this water like residents on public water, there is a municipal responsibility to protect ground water from contamination. Septic systems for wastewater disposal in areas with wells are a concern. Bart voices a perspective shared by other municipal officials that connecting residents with wells to the public water supply is a preferred strategy for addressing the risk, uncertainty and liability associated with contaminated wells. Land use policies to prevent contamination were not proposed as a solution.

The public drinking water source that Bart refers to is a brook fed primarily by groundwater recharge. The recharge area of the public water source has been mapped and is protected by special zoning in Bart's town. Bart sees drinking water coming from an interconnected system where water moves from the surface down to ground water reservoirs.

> *There's two ways that we get water in town. One is through the municipal water service, which comes from our own watershed – water that users buy, and the second way that residents get water is through wells. If it's coming from the watershed, we've got specific zoning to protect those watersheds and what goes in there.*
>
> *Then the second scenario deals with your wells. You've got your subsurface waste disposal systems that obviously are putting treated effluent or distilled effluent down into the ground again. And you're using the natural gravel or clay base to filter that water. It's important from both those perspectives that it be managed not only for the watershed but you've also got to manage it for the construction that goes into the areas where public water is not available.* *Bart, Town Manager*

Ben is the technical services director of the local water district. For him, *water as commodity,* is his core responsibility. When asked why water was important, he answered:

> *Well, for us I think the answer is obvious. Our mandate and our mission is to provide safe, potable quantities of water for the communities that we serve. That's the utmost importance to us and that's what we're required to do and that's the focus of everything that we do here so… In terms of why we own land or how we interact with the communities we serve, it's all on a basis of protecting, as we think the needs are, in terms of protecting water quality and insuring that we are able to adapt to the wild water that is given us by Eel Brook and being able to treat it and be sure that it's safe and potable for our communities. So, in terms of how we view our mission, quality of water resources is… that's the Holy Grail for*

us. Obviously it's what people expect of us. Ben, Technical Services Director Local Water District

Ben's reference to *wild water* was unique among interviewees. I asked him to tell me more about wild water.

For us wild water is whatever is given to us - behind the plant. We have a water supply that is a spring-fed stream that is wild water quality… is variable depending on what's going on. If it rains, we have a high sediment level. The brook color changes, in some cases to chocolate milk so… In terms of what the plant operators have to deal with, they have to continually test the water coming into the plant and adjust chemical application rates, chlorine dosages, whatever they have to do to make the outgoing water consistent. Because that's what we strive for - the end product to be consistent and meet all the regulations. But the incoming water, especially in the stream supply… the surface water supply is, at times, very dirty. In terms of wild water, it's, "What have we got today to deal with?" Ben, Technical Services Director, Water District

A few interviewees mentioned the increase in the use of bottled water in recent times. Motivation for this is ascribed to both taste and a feeling of distrust of public sources of drinking water. This distrust arises despite rigorous federal standards for public water sources.

At the time I interviewed Lee. He was new to his Town Planner position in Maine having previously worked for a regional planning commission near Lake Winnipesauke in New Hampshire. One of his responsibilities in New Hampshire was aquifer and source water protection. Although he didn't use Ben's term, *wild water*, he talked about the same qualities of source water and the costs associated with drinking water production. Protecting water proactively, "from the beginning" is less expensive than treating contaminated water. In this cultural model, water is a raw material collected from nature in a condition that varies in quality from day to day. As with other commodities such as agricultural products, water must be processed according to regulatory standards as well as meeting consumer taste standards.

Obviously drinking water is important. I did a lot of work with the regional planning commission where I was working on aquifer protection particularly of ground water and drinking water, related to drinking water. It's obviously incredibly important…when you've got such limited water resources as we do.

I: So you see them as finite?

Certainly finite but also the… the more pollution that goes into the water, the more we have to treat it and the more we have to treat it, the more

costly it becomes and the more byproducts that are produced, creating the chemicals remaining drinking water. If we can protect the water as much as possible from the beginning you don't have to wind up in that situation.
Lee, Town Planner

Lee talked about the condition of Lake Winnipesauke as a drinking water source and about changing attitudes toward bottled water. Contaminants associated with petroleum fuels from recreational watercraft threaten drinking water. In Lee's opinion, the use of Lake Winnipesauke for motorized recreation is a higher priority economically than the use of the lake for drinking water. Contaminated drinking water can be treated at the plant; if that fails people will turn to bottled water. I asked him if contaminated drinking water would have an affect on tourism.

I don't think that that would stop any tourist from going there. I highly doubt it. In the end, you know it's treated enough and bottled water is always there. And we know that for whatever reason more and more people are drinking bottled water, even people that are on fully treated water systems have opted to go with bottled water for their drinking water and only use the city water for showering, watering the lawn…It amazes me, too, because to me if it's treated, I'm pretty happy with it because it doesn't taste like chlorine. And that would happen sometimes. I've had water before where they've had to up the … treatment of it and you can taste some of the chemicals. It doesn't bother me. *Lee, Town Planner*

Ann describes the importance of trusting a water source and is concerned about increasing trends to ship water away from local watersheds.

First of all we need water for drinking. That probably is the most important aspect of why water's important. Although I do drink bottled water, I don't like the fact that it's bottled and actually taken to different places. As my husband said, "Why does everyone carry around a bottle of water now? We never used to do that?" And I don't know if that's because we don't trust the water, municipal water that we might find in other areas. I've traveled enough that I know that there are some places you don't drink the water unless it's bottled. But that's actually rare today unless you go to some serious third world countries.

But the fact that water is taken out of Maine and sold somewhere else, and vice-versa, I think that that's something that we should worry about. The fact that you don't even know where the water comes from. Poland Springs says "Poland Springs" but I know it doesn't come from Maine; it comes from springs in other parts of the country.
Ann, Planning Board Member

Water is a commodity is nested within the larger cultural model that *water is a resource for humans to use and manage.* The decision to present these two

cultural models separately is based upon the importance that this aspect of using water holds for municipal officials. Talk about drinking water also revealed how economic tradeoffs can be a source of ambivalence and conflict in thinking about water for drinking and water for other economic uses.

Analyzing the transcripts revealed dueling pathways for reasoning about protecting drinking water supplies from contamination. As Lee describes in the excerpt above, clean drinking water is "incredibly important." Yet, he doesn't feel that jet skis that impact the quality of drinking water from the lake would ever be banned because of the tourism dollars they bring to the state. Contamination in the lake can be removed through treatment and "there is always bottled water." The economic ball bounces back and forth in his head as he later explains; that protecting water "in the beginning" alleviates the economic burden of treating contaminated water later.

Key elements of the *water is a commodity* cultural model are summarized in Table 3. These key elements provide empirical evidence for reasoning about municipal water supplies that can explain some land use decisions. The concepts that people can always be put on city water, there will always be another source to tap, and that water can always be treated to remove contamination provides a rational for allowing land uses that could potentially impact water.

Table 3. Summary of key elements of the cultural model *water is a commodity.*

Key Element	**Aspects of Key Element**	**Perceptions That Vary**
Water comes from a raw or wild source.	<u>Spatial</u>: <u>Ownership</u>: Surface water Public Utility Ground water Private Local Commercial "Away"	Awareness of source Trust of source Ownership of source Condition of source
Water is collected, processed and delivered to the market	Guided by regulations & standards Market demands Conflicting land uses degrade quality Public vs. commercial	Finite Resource to Protect vs. • Purification using technology and $ • There will always be another source to tap into Concern for shipping water "away"
Final product is evaluated by users	Taste and Appearance Image Distrust of municipal/tap	Current trend to prefer bottled water
Municipal Responsibility	To provide water To protect private wells through land use regulation Liability	Put households on public water to reduce liability associated with contamination.

5. Water is landscape

People are drawn to the intrinsic value of water in the landscape as a source of beauty, adventure, peace and serenity. Water landscapes are valued both as backdrops for residential and commercial properties and as sources of more intimate experiences of *re-creation* like fishing, swimming, and boating. Just knowing that a favorite place in nature with clean water *exists* is a source of satisfaction.

This cultural model of water captures the aesthetic and spiritual value of water in a natural setting. Water places are valued actively and passively. Interviewees frequently talked about water in terms of memories of times spent near water.

> *I kind of think water quality is important from a variety of levels…on the first level is the intrinsic value of water. Kind of what you can't qualify. Maybe that's what you're trying to get at now, too, is you know it's not just being able to participate or be in the water or fish from it or recreate with it or extract from it, it's also that kind of recharging, you know, that you get being… either having access to the water and just saying, "Ahh." Or, it's having a house that may be waterfront and that every year you wake up and you see this. I mean these are values that… obviously there's an economic value with having property there but it's also that value that says "this is what gives me my being, my soul, whatever you might call it. That's one of the other levels I look at it from as far as water.*
>
> *Jack, State Watershed Program Manager*

The spiritual quality of water places is reflected in Lee's interview as well.

> *I think associated with the economic side of the thing as well is the wildlife, flora, fauna that comes with it. Not just for its intrinsic values but also that that's something that I think people do value and treasure so that when they go to the River to go on a kayak trip or go to the ocean, they're not just going for the water but those… for those other – the flora, the fauna, the esthetic values that come with it.*
>
> I: Could you say more about what you mean by those intrinsic qualities?
>
> *It would almost be the intangibles, in many ways, that just come with water – serenity, peace. There's nothing like sitting out on a beach chair and hearing the water. I've got friends that live in Waveland and I have a summer place there. That is very… it's just something that's with water, you can't really put a finger on what it exactly is but it's there and you wouldn't get the same experience in many other places.*

There are people, I think, that always flock to water or purposely live in places…I think that certain people do value that, just for the sake of being close to water or the recreation opportunities it brings for that. You can't put your finger on it but it's there. *Lee, Town Planner*

People interact with the landscape when water is used for recreation. Water dependent recreation and tourism are tied to the effects that interviewees ascribe to time spent near water places - peace, and serenity, intrinsic value that they can't always name. Passive or low impact water recreation such as swimming, recreational fishing from shore, canoeing and kayaking generates less conflict among users than higher impact adventure recreation including motorboats and Jet Skis. Noise and pollution associated with these forms of recreation were mentioned because they disturb the enjoyment of others and threaten drinking water sources.

The *water is landscape* and *water is a resource for humans to use and manage* share common attributes connected with ideas about recreation and water-based tourism. The interview transcripts provide clues about the relationship between these two cultural models. The economic value of water as a landscape feature is the link. Jack, an environmental planner and Ward, a Town Manager described the connections between water as landscape and economic value, and the importance of water quality to the value of that landscape. In Jack's case the landscape is recreational in Ward's the landscape is a backdrop for residential and commercial use.

In addition to the resource-based economy there's also the economy that's based on recreation. And without having these opportunities, if the entire State of Maine were nothing but filthy water we wouldn't have the tourism here. Maine would no longer be called "Vacationland". You wouldn't have people coming here to go whitewater rafting if the water wasn't clean, or rafting in or on it if it made you sick.
Jack, Environmental Planner

Ward gave a specific example of how his town used the landscape around a local brook as a focal point for a business park, preserving land around the brook for a system of trails to make the site more attractive for businesses, offering the brook and trails as an opportunity for renewal and recreation as part of the economic value of the site.

That area around the brook is a business park development. Around the brook, that area is segregated for preservation. There are actually trails there that people can walk. So if they're business people or… there's a nice neighborhood right next door, and those people can meander in there. I think part of the development was to have a trail system. So both from the residential component and the business component, if you're staying in the hotel, if you're a corporation and your people want to take a walk at lunch. But it's an amenity; it sort of goes back to your first thing, how important water is. And that's an amenity that, to me, an attractive

one to, again, quality of life in that neighborhood. As I say, we named the park, the business park after the brook. So that's a part of project.

Ward, Town Manager

The issue of dogs on the beach, a hotly contested issue for southern Maine demonstrates how variations in the way people enjoy recreation and water as landscape can have consequences for water quality.

Just knowing it's here. It's like going down to the beach here, you know. I haven't been down yet this year . . .I grew up in Washington County and we had the ocean to ourselves. . . It's changing but it's still nice when I go down because if I want to have a nice quiet walk on a beach. I don't want to see other people with dogs and kids. I just want to enjoy listening to the waves breathing in the salt air. And I don't get that same experience here so that's probably why I don't go down.

George, Project Manager for Developer

…There's a conflict coming, I think, locally on dogs on the beaches that New Hampshire, at their state parks, have banned dogs. So, there was a fight in Kittery because what was happening is all the New Hampshire people are coming over the bridge and then using Kittery's beaches. And so they went and the local city council was gonna vote on banning dogs on the beaches and then all these dog owners came out and so it turned out to be a real heated meeting. But the same thing is happening locally.

And it's in the water. And it's there for that tide; it's there for the following morning. So I think what's probably gonna… the first red flag that's gonna occur, is that there's gonna be some sampling done and that's… that's gonna be there. And even though people are good with their little Baggies picking 'em up… And I've talked to the lifeguard and they said that the stands just reek when they come in there in the morning because the dogs head for where ever they can lift a leg and they said it just is overwhelming. And that's there for the next tide coming in. So I think one of the policy things people are gonna have to face is that the first time you have a beach closed or you have a warning and it's because of dogs then it's gonna become a debate. And I remember a letter to the editor in one of the local papers where the person was talking about the civil rights of her dog.

So I think that's probably coming, you know. And it's interesting to watch on a really hot day, when the beach is crowded and then five o'clock comes along and you've got these dogs going all through the areas where the kids still are. Our kids are still playing. I think we're gonna start having alarms go off the first time there's a bad rain and then you're gonna have the day that people where their dogs are their child substitutes

and then people saying, you know, "The economy and the quality of life require that we've gotta have a safe, clean beach."

And all it takes is one bad reading and you get a reputation of a beach… I'm trying to think of the name of the beach up in South Portland, Portland where hypodermic needles keep coming up.
Mack, Coordinator local office of Senator

To dog owners, the beach is a recreational platform enhanced by proximity to water. Other users of this water landscape have concerns about dog waste as a health hazard to humans swimming at the beach. Bird watchers looking at the same water landscape, see both humans and dogs as problematic for migrating and nesting shorebirds. In each case the water landscape has meaning and is appreciated for different values. Both swimmers and dog walkers are using the water landscape. The bird watchers are seeing that landscape through the lens of the first two cultural models. The water landscape is habitat for species of plants and animals that are dependent upon them for survival.

6. Water is waste

Water used as a resource and contaminated as a result of that use becomes waste. Water also becomes waste when it is used as a deliberate or incidental receptacle for pollution. Water's job is to carry waste away to be diluted. Contaminated water threatens public health and wildlife and looses value as a resource. Water that does not filter into the ground can create a safety hazard on paved surfaces.

Two qualities that make water waste are contamination and undesirability. When water occurs in places where it is not wanted, for example, for health or safety reasons on paved surfaces like roads or airport runways, the goal of the water manager is to move the water off. My interview of Les, a Highway Department Manager included a driving tour of the town from the highest point in town along major roads to the ocean. Les showed me the path of water as it moves through town toward the ocean. At stream crossings, culverts and drainage swales he repeated the mantra, "I have to get the water off the road."

Of course, I kind of have to watch when I start running water - what water supply you're running it into. If you run it into the ocean that's a little different then, let's say, Eel Brook because Eel Brook is our water supply. I have to have it off the shoulders of the road and into the ditches. You've got the problem of making sure you're not running it across somebody's property line and into their well. In the back country up here, where's there isn't town water, the streets are so close to the roads that we've got to watch for their wells… run it to the nearest point we can get by without putting it into somebody's well. *Les, Highway Manager*

The above quote refers to moving rainwater and the chemicals it carries off the roads. Les's job was complicated when water was contaminated with pollutants from a gasoline

spill at a local service station. His knowledge of the town's stormwater system and the path that the spill would follow allowed him to take effective action to keep the spill from reaching the river.

> *All my drains run right from there right into the river, down along and into a river. It's been that way for years. But what I did was, I went to the last one that I knew where it went, before it went into the river. I happened to have a place there that I could block it off before it went across the road and down into the river. And we put the pads and everything there plus all the other manholes we plugged… put pads around them so that everything was confined to that area. Then all they had to do was clean the pads up.*
>
> *Les, Highway Department Manager*

Cherie is a Town Engineer who oversees construction projects. In her work, water is waste occurs when projects alter the landscape to increase the speed and amount of water leaving a site, thus intensifying the erosive force of the water. Cherie's job is to work with project managers as they design, construct and manage commercial and industrial projects in the town to slow the force of water, encourage infiltration and prevent runoff from leaving the project site.

> *Our ordinance states that we're not supposed to increase flow rate onto an adjacent property greater than what it currently exists in its natural state. That means that a project has to detain water for a period of time in order to allow that rate to decrease to a point that won't cause a negative effect on the next property of flooding; a rate that is so high that it's going to now erode the channels that have been there for years. So we try to look at it from those two perspectives as much as we can to try to keep impacts to a minimum - the flow and erosion. Cherie, Town Engineer*

Gary is a state regulator tasked with enforcing Maine's water pollutions control laws, the same laws that Cherie works with at the town level. These regulations seek to minimize disturbance of land that results in erosion and reduce the impact of runoff water that picks up chemical contamination as non-point source pollution. Gary's quote connects economic impacts with water that becomes waste.

> *What I deal with on a daily basis, just regular old dirt and nutrients getting in and causing poor water quality – may not be directly harmful to us as people but starts to degrade the water quality to the point where we can't derive any recreation, any pleasure from being around water bodies, with fishing industries and recreational fishing. Swimming opportunities all decline. Property value goes down. Gary, Regulator*

The *water as waste* cultural model is conceptualized two ways. The first way is illustrated by the examples above. Moving water off of roads, controlling the behavior of water, keeping water on construction sites, and minimizing impacts of contamination from stormwater, described by the three people above, are fundamentally different from

the job of managing wastewater from a wastewater treatment facility. Point sources of pollution are not the focus of this project. However, because municipal wastewater treatment plants frequently accommodate stormwater, they are an integral part of water management.

For the water is waste cases described above, the natural system is the source of the water; professional efforts are focused on maintaining the quality, quantity and flow of water as it moves through the human dominated landscape. Non-point source pollution is a by-product of other actions, not a deliberate discharge of waste.

Lewis is the manager of a municipal wastewater treatment facility. His professional career spans almost forty years. His was the only interview directly related to point source pollution of water. The relationship of his work to the hydrologic cycle illustrates the second way that interviewees conceptualized the *water is waste* cultural model. The treated effluent from municipal wastewater plants is the combined waste from residential, municipal, commercial and industrial activities that must be reintroduced to the hydrologic cycle by placing it into a receiving source in nature.

The relationship of the function of a wastewater treatment system to the *Water and land in a natural state, linked as a watershed, function as a water purification and storage system* cultural model is that this job requires understanding the limits of nature's water purification system, in order to maximize the use of that capacity as a receiving body for waste. Lewis's job is complicated by regulatory constraints designed to maintain water quality. He views those regulatory constraints as based upon imperfect science. He is also concerned that the technological ability to detect contaminants has outpaced the economic capacity to remove the unwanted chemicals.

Lewis described the characteristics of the receiving body of water and the constraints he faces when discharging wastewater into the estuary. Regulations have tightened; technology has lowered detectable limits of contaminants in water at the same time that the complexities of chemical products and pharmaceuticals, and quantity of wastewater have increased. Lewis described increasing conflicts over water use and wastewater discharge and emphasized that the ideal state of clean water in nature can never be attained.

> *I think it's important that we understand it's never gonna be perfect because, unless we, as humans, disappear we're gonna have impacts to the water systems…*
>
> *Our interest is in the estuary because that's where we discharge. As part of our discharge license, they base what can be discharged to a river or estuary on a factor called 7Q10. This is a 7-day low flow in a ten-year period. That's a pretty extreme type of standard to be looking at, because you're talking about over a ten-year period, the lowest 7-day period.*

One of the things that they look at is known as a dilution factor. And our license is based on a 7Q10 at 15 cubic feet per second coming down the river. The dilution is a key to the health of the estuary. River systems have a certain assimilative capacity and by calculating what the dilution factor is, from that they can calculate what safely they believe the river can assimilate.

This minimum flow is certainly an important factor. There are diurnal swings in the dissolved oxygen {DO} in the river. A lot of discussions have been right around what is actually happening out here in the river. There's data that's been collected ten years ago that indicates that during certain periods of the day you have the DO swings where it doesn't meet the standard.

Summer, warm weather, early morning, low-flow periods. There's a lot of very conservative type of factors that are occurring all at once. The DEP uses a model to determine that. You're plugging in all the conservative assumptions then you're really looking at… it's more than a worse case scenario. Because of all the conservative assumptions that have been made it's very unlikely that all of those factors are going to occur at the same point in time and space.

Lewis, Wastewater Treatment Plant Manager

In the case of wastewater treatment and industrial or manufacturing processes, water becomes waste as a direct consequence of its use as a resource. Lewis and others using this cultural model think water's job is to remove wastes and carry them away to be diluted.

For both Lewis and Spencer (p. 20), humans are an undeniable component of the municipal water management system. Pristine conditions do not exist. They begin their reasoning about water management from this premise. They work to maximize their use of nature's water services to get their jobs done.

Jack and Cathy, state level water program managers quoted on pages 16-18, orient their actions to water with their cultural model, *water and land in a natural state, linked as a watershed, function as a water purification and storage system.* This model uses a pristine watershed has a reference or ideal type. The differences in these two models are important factors to include in the design of education and training. Jack and Cathy, in their roles as state level program managers communicate with municipal officials like Lewis and Spencer. Understanding that the premises underlying their reasoning about water begin from fundamentally different perspectives has implications for framing issues of mutual concern.

II. Perceptions of Threats to Water -A Cultural Model of Risk and Loss

> *People move to Maine from really built up areas and want to bring the exact same design, suburban design, here to Maine which historically has been more rural, rough, didn't demand green lawns right down to the water's edge. Instead of leaving a nice rough undisturbed area along the riverbank, the suburban type development demands full visibility of the water and wants a shockingly green lawn all the way down to the water's edge, which demands fertilizer and which cuts all the trees and all the vegetation that helps to protect the river. Bernice, Town Planner*

> *You've got that under every car there is. I don't care what it is. You can't get it all. People spill gas when they fill their tank; they spill it out on the ground and then that goes somewhere and it's on their car and then it washes off and goes down inside the drain or it goes down the road somewhere else. So it's… that's the way it is. Les, Highway Department Supervisor*

> *As far as water quality, I think a lot of people think that we've got water coming out our ears because of the forested wetlands and also because of the aquifers that we have in town. But I don't think they realize that, you know, the aquifers can go away. Ann, Planning Board Member*

The excerpts above capture some of the ways that interviewees, people involved with water management in Southern Maine, think about and describe threats to water. In the first quote, a Town Planner highlights how the practices of newcomers "from away" threaten water through a combination of increased chemical inputs and land use that decreases nature's ability to protect water. This quote reflects the attitude that the construction of what locals call "McMansions," or trophy homes, are perceived as posing more of a threat to water quality than the smaller traditional, lower impact homes they replace. The Highway Supervisor in the second quote acknowledges the ubiquitous and unavoidable threats to water that come from everyday actions associated with maintaining and operating cars and car habitat. The vulnerability of local aquifers is a concern of the Planning Board member who feels that her concern is not shared, indeed, that "a lot of people" have the opposite idea, that there is an overabundance of water.

Southern Maine is a landscape in transition. Changing land use associated with development was perceived as a threat to water quality by all of the interviewees. Awareness of threats to water *quantity* was not a widely shared, lending credence to the view of the Planning Board Member quoted above. Knowledge and values, affect the perception and attitudes toward threats. This cultural model for threats to water was developed from grounded theory analysis of the interviews with municipal officials, water managers and scientists working in southern Maine.

The cultural model of threats to water contains six components:

- Categories of Threats
- Source of Threats: as places, institutions and practices
- Movement of Threats
- Target of Threats
- Losses Resulting from Threats
- Root Causes of Threats

These components are organized into a cultural model displayed as a causal sequence in Figure 1. The causal sequence structure of the cultural model allows it to be used to mentally process information about threats to water. This causal sequence is used to evaluate, categorize and understand threats. Interviewees shared the basic structure of this cultural model. Variations in the ways people *fill in* the components in the causal sequence are described below.

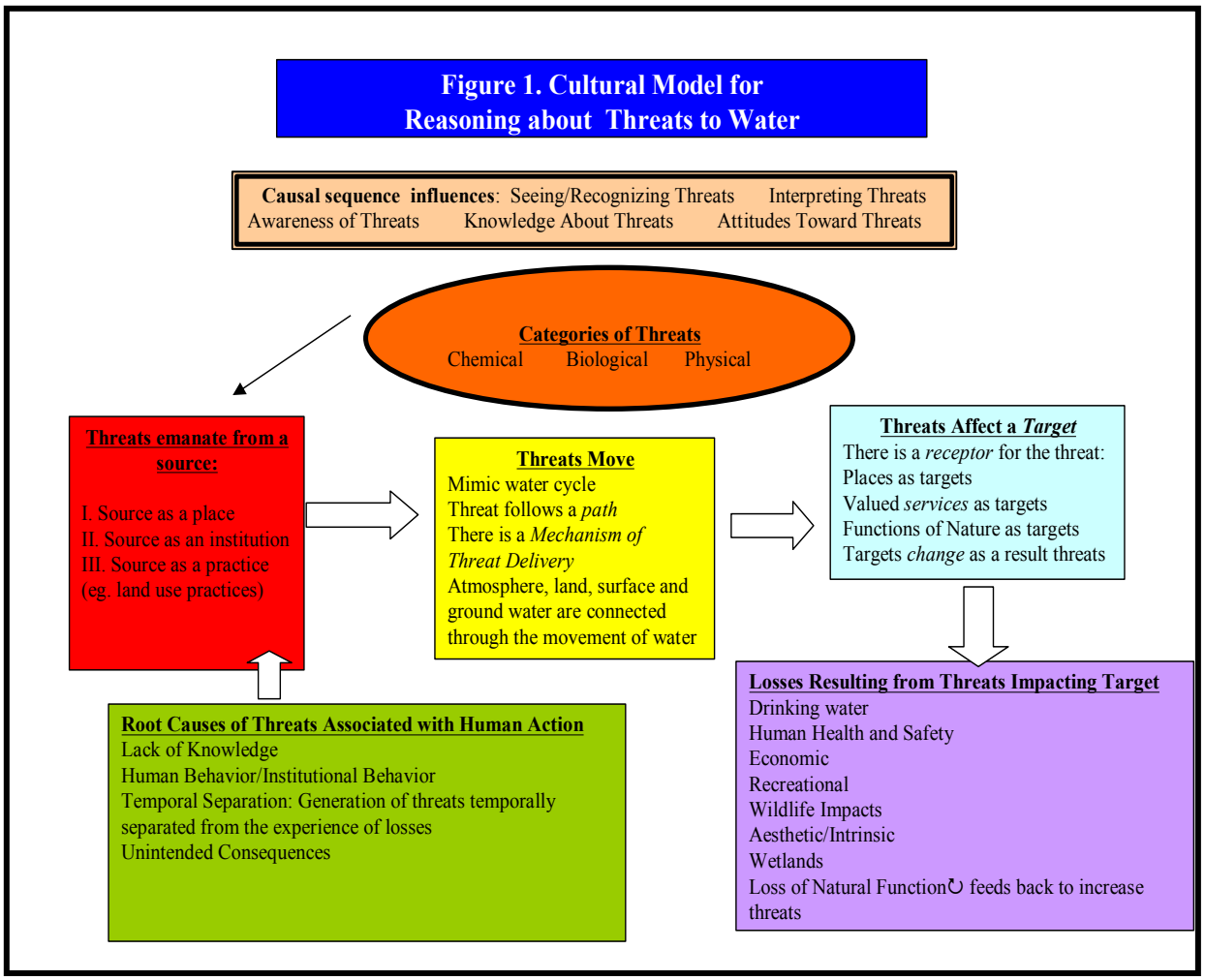
Figure 1. Cultural Model for Reasoning about Threats to Water
Causal sequence influences: Seeing/Recognizing Threats Interpreting Threats
Awareness of Threats Knowledge About Threats Attitudes Toward Threats
Categories of Threats
Chemical Biological Physical
Threats emanate from a source:
I. Source as a place
II. Source as an institution
III. Source as a practice
(eg. land use practices)
Threats Move
Mimic water cycle
Threat follows a path
There is a Mechanism of Threat Delivery
Atmosphere, land, surface and ground water are connected through the movement of water
Threats Affect a Target
There is a receptor for the threat:
Places as targets
Valued services as targets
Functions of Nature as targets
Targets change as a result threats
Losses Resulting from Threats Impacting Target
Drinking water
Human Health and Safety
Economic
Recreational
Wildlife Impacts
Aesthetic/Intrinsic
Wetlands
Loss of Natural Function↻ feeds back to increase threats
Root Causes of Threats Associated with Human Action
Lack of Knowledge
Human Behavior/Institutional Behavior
Temporal Separation: Generation of threats temporally separated from the experience of losses
Unintended Consequences

Categories of Threats

When interviewees talked about threats to water, they began by naming specific types of threats. The threats named fit into three categories, chemical, biological and physical, shown in Tables 4 & 5. These tables reflect the initial study design that divided interviewees into two categories. Detailed information on interviewees appears in Appendix I. *Experts* included managers of state level water programs, an environmental regulator and an ecologist. *Municipal Officials* included managers, staff and members of volunteer and elected boards working at the town level. The use of the term *expert* was initially intended to refer to specialized knowledge about water held by this group of interviewees that may not have been shared by municipal officials.

Tables 4 & 5 provide evidence of the shared knowledge the interviewees possessed about categories of threats to water. The similarities in the lists overshadow the differences. Only the expert list includes endocrine disrupters, drugs, PAH's (poly aromatic hydrocarbons) and invasive species. Only the municipal list includes MTBE and wildlife and domestic livestock waste. These differences may reflect aspects of the open-ended interview process more than differences in knowledge between the two groups.

Source of Threats: as places, institutions and practices

After naming categories of threats, municipal officials proceed to describe threats with reference to places and practices in their local landscapes and types of land use associated with those places - where do threats *come from*. Residential, agricultural, commercial, industrial and public infrastructures were associated with specific practices that produce pollution. Pesticides *came from* residential lawn care practices of homeowners. Oil and gas *came from* automobile use, roads and parking lots. Sediment *came from* construction sites where bare soil is exposed.

Municipal officials referred to specific local places as sources of threats. Local places also provided observable evidence of environmental change that was used as evidence for threats. A gravel pit normally full of water that has been "down" for years is used as a

reference point for reasoning about cause and effect relationships. These cause-effect relationships were developed idiosyncratically – Maine is experiencing a drought; the trailer park is using more water; the town redirected runoff that was recharging the aquifer.

When asked to describe threats to water, the Town Manager quoted below takes a mental tour of his town from the beach, inland to the less developed part of town as he talks about water. He identifies places, and threats that come from the practices associated with those places. The Indian Crossing Road Site, 60B, and the Smith property are former landfill sites that are current sources of groundwater pollution. Landfills created in the 1950's and '60's were located in what had been remote sections of town. The institutional practices of business and government of that time consisted of generating and disposing of waste in open pit landfills. The landfills, closed in the 1970s became the source of threats associated with groundwater contamination in the mid 1990's. Houses built adjacent to the landfill experienced well contamination. The town purchased properties near the old landfill site when groundwater contamination spread from the municipal landfill site and made residential wells unusable.

Figure 1. Conceptual Framework for Reasoning about Threats to Water

Framework influences: Seeing/Recognizing Threats Interpreting Threats
Awareness of Threats Knowledge About Threats Attitudes Toward Threats

Categories of Threats
Chemical Biological Physical

Threats emanate from a source:

I. Source as a place
II. Source as an institution
III. Source as a practice
(eg. land use practices)

Threats Move
Mimic water cycle
Threat follows a *path*
There is a *Mechanism of Threat Delivery*
Atmosphere, land, surface and ground water are connected through the movement of water

Threats Affect a *Target*
There is a *receptor* for the threat:
Places as targets
Valued *services* as targets
Functions of Nature as targets
Targets *change* as a result threats

Losses Resulting from Threats Impacting Target
Drinking water
Human Health and Safety
Economic
Recreational
Wildlife Impacts
Aesthetic/Intrinsic
Wetlands
Loss of Natural Function↻ feeds back to increase threats

Root Causes of Threats Associated with Human Action
Lack of Knowledge
Human Behavior/Institutional Behavior
Temporal Separation: Generation of threats temporally separated from the experience of losses
Unintended Consequences

Ethnopsychologies of human behavior & learning. {Includes ways CM are barriers to communication/learning.}

Table 4. Categories of Threats Municipal (n = 15)

Chemical	Biological	Physical
➢ Lawn Chemicals ➢ Petroleum and Car byproducts ➢ Asphalt ➢ Nutrients, N and Ph ➢ Fertilizer ➢ Ammonia & Chlorine from Sewage Treatment Plant (STP) ➢ Mercury ➢ Atmospheric pollutants ➢ MTBE ➢ Arsenic ➢ Pesticides ➢ Road salt, sand & deicing chemicals	➢ Human sewage ➢ Domestic Livestock waste ➢ Pet Waste ➢ Wildlife Waste ➢ E. Coli ➢ Red Tide	➢ Temperature ➢ Amount and force of flowing water ➢ Garbage ➢ Sediment; silt; soil

Table 5. Categories of Threats Experts (n=5)

Chemical	Biological	Physical
➢ Lawn fertilizer ➢ Petroleum ➢ Nutrients, N & Ph ➢ STP by-products ➢ Acid rain ➢ Mercury ➢ Air depositions ➢ Drugs via septic and sewer ➢ Heavy metals ➢ Hydrocarbons ➢ Organic compounds ➢ Inorganic pollutants ➢ Pesticides ➢ Herbicides ➢ Hormone disrupters ➢ PAH's	➢ Bacteria ➢ Medical waste ➢ Sewage ➢ Yard waste ➢ Red Tide ➢ Pet Waste ➢ Invasive species	➢ Sediment ➢ Trash ➢ Amount and force of flowing water

Annotated excerpt**:** italicized and underlined passages are *place references***;** concepts in bold are **sources of threats associated with human practices**

"Well, I think of water as needing to be of the highest caliber of quality both from the standpoint of swimming off *our beaches*. That's why we have… prior to the federal/state program, we got the water tests, to joining and being a part of the Maine Healthy Beaches program of the state and federal EPA testing of ocean waters for swimming. With that said, we are a barrier beach, tourism driven community, highly **densely populated** in the *beach area*. Because of that we have a sanitary sewer system, within the barrier beach system, and public drinking water.

And not only are we concerned with water quality being of a caliber for swimming, but *as you move from the beach inland*, the marsh area is extremely important to us because of the shellfish… that's making sure there are no **open septics and things that would cause the counts on the water to be contaminated** to prevent the shellfish harvesting from going forth.

We also, *as you move inland*, our concern is with **runoffs** into the streams and estuaries that flow into the river and then out into the ocean with **pesticides** and we have participated in the Reserve's watershed testing programs and there are more elaborate testing programs {microbial source tracking} at a time to determine if the **coliform issue is a manmade or wildlife issue**.

…*as you move further inland* from there, say on the other side of Route 5 and the other side of the turnpike, as **development** occurs it's very apparent that we're running into water quality problems for those who are building on single lots and other places, and finding problems with *old landfills, like a 60B.*

That over time and over our testing period have discovered that the quality of life, because of poor water quality and other issues, has been costing the community a lot of money. And to clean up all of the *Indian Crossing Road site, the Smith property*, has been an achievement to contain that and make *that neighborhood*… assured that they were living in a clean environment.

So, what we are slowly doing is, as a community, looking at our past and trying to correct the wrongs we have made and moving forward trying to think through ways in which a **development** that's occurring in the town is done in a more efficient or more environmentally friendly way. And that's the challenge facing us because the market conditions and the educational levels of people's understanding this are at a point where we would lose if we suggested anything out of the ordinary to be done." Jim, Town Manager

The five experts interviewed did not refer to specific local places when they described threats to water. Generic references covered the same kinds of places and practices that municipal officials listed: residences, farms, roads, and construction sites. Table 6. is a summary comparison of sources of threats named by experts and municipal officials.

Table 6. Summary of Sources of Threats - Expert Comparison with Municipal Officials

Place (shared with MO)	Practice (shared with MO)	Comments
Individual Residences Subdivisions	Lawn care with chemicals, Chemlawn Residential Chemical spills Failing septic systems Stream abutters dump yard waste in streams, smothering natural vegetation and killing it, resulting in erosion and nutrient pollution.	People disconnect "my actions" and water quality. The threat is everyone. Chemicals available for all to buy and apply.
Farms	Agricultural runoff from domestic animals, pesticide applications, fertilizer application	Farmers have dump sites on their land
Municipal & State Infrastructure: Roads, parking and pavement	Road building and repair Car chemicals on roads Creation of impervious surfaces Road salting	
Sewage Treatment Plants	Heavy metals released in effluent Sewage treatment by-products released in effluent	By-products of drugs people take (expert only)
Commercial Business, Retail	Parking lots; commercial processes Creation of impervious surfaces Hazardous materials released in wastewater	
Industry	Industrial Waste created as a result of processing	
Construction Sites/Development	Building residences, roads, commercial sites Erosion from cleared soil Destruction of plant cover	

Place (shared with MO)	Practice (shared with MO)	Comments
Natural Sources	Chemicals in nature; Natural erosion of sediment;	Nutrients piggyback on sediment
Contaminated groundwater		Lack of understanding about ground water
Recreational Boating	Boating	
Atmospheric (Global/Midwest)	Global threats like acid rain and mercury Energy Productions	Recognition of connection of atmospheric and water threats
**********	**Threats Listed Only by Expert**	**********
Golf Courses	Pesticides and Nutrients	
Storage of heavy metals in below ground portions of plants	Contaminants accumulated by plants, may be released through decomposition, export to estuary	
**********	**Threats Listed Only by Municipal Officials**	**********
Underground Storage Tanks	Leaking from businesses or residences	
Gas Stations and Roads	Spills	
Junkyards		
Regional Airport		
Recreational ATV Trails	Off trail riding in streams and waterways	Contributes to erosion and sedimentation
Historical sources	Abandoned Municipal Landfills	Groundwater pollution; municipalities bear financial burden
Hydro Dams Upstream	Affect movement of water, sediment	

Movement of Threats

Water is movement. Through that movement, water connects everything on earth temporally and spatially. Hydrologists model the concept of water movement in the hydrologic cycle. Interviewees talked about water in ways that demonstrated their knowledge of the hydrologic cycle. Not all interviewees used terms associated with the water cycle, such as infiltration and sheet flow. They all displayed knowledge of the way water moves over, across, through and under the land.

Reasoning about threats to water reflected the use of the concepts of source and target. Those concepts were connected by ideas about how water moves, the path it follows and what it carries as it moves. Water follows a path influenced by topography and can be abetted or blocked by public infrastructure including gutters, storm drains culverts and retention basins. Water acts as a delivery mechanism moving threats directly, as in an oil spill, or indirectly in the case of plant nutrients, nitrogen and phosphorus adhering to soil particles in lawns and agricultural fields.

Petroleum particles adhere to soil near parking areas and roads, following infrastructure that treats *water as waste* to be disposed of. In the case of the stormwater drainage system for a busy section of Route 1, spilled gasoline spill from a local gas station followed the same path designed for water runoff - toward the river. Quick action by the Highway Supervisor, based upon his knowledge of the movement of water in "his" system, resulted in minimal impact to the river. This example shows the role of local knowledge of the movement of water as a tool for municipal water management.

> *All my drains run right from there right into the river, down along and into a river. It's been that way for years. But what I did was I went to the last one {catchment basin} that I knew where it went before it went into the river and I happened to have a place there that I could block it off before it went across the road and down into the river. And we put the pads and everything there plus all the other manholes we plugged… put pads around them so that everything was confined to that area. Then all they had to do was clean the pads up.*
>
> *MO7 Highway Supervisor*

Understanding of the *time scale* of water movement was not as conceptually developed as the *directionality* of water movement. Temporal aspects of water movement combined with the *invisibility* of water movement underground and through the atmosphere represent aspects of the hydrologic cycle that are were less salient for interviewees. All interviewees talked about water and threats that move across land into surface waters. Not everyone discussed threats in relation to groundwater or atmospheric deposition.

People talk about threats in terms of the losses they produce. When threats reach a target, the target responds or changes resulting in losses such as closure of clam harvesting or swimming beaches. Time plays a factor in reasoning about threats. The generation of threats may be temporally separated from the experience of losses in ways that influence actions that could be taken to protect against the losses. The temporal separation may be

the result of the slower, less visible rate of flow of groundwater or the time required for development pressure to be high enough to make rural properties on top of landfills profitable.

Threats Affect a Target

Targets for threats represent the *receptor* of the threat - where the threat goes and to some degree what happens when it gets there. Targets can be a place, such as the popular Goose Rocks Beach in Kennebunkport, Maine. The target can be a valued service - swimming at Goose Rocks Beach in July and August. The target can be an ecological function of nature - the ability of the Little River to dilute pollutants before they reach Goose Rocks Beach. When threats reach a target, change is perceived as negative. During the summer of 2005, fecal coliform counts detected at Goose Rocks beach exceeded health standards and the beach was closed to swimming.

The ecologist interviewed provided a variation on the idea of a target. She discussed the way marsh plants and peat can sequester nutrients or pollutants, such as heavy metals.

> *M: Most of it has to do with nutrient loading affecting primary productivity in the food web. I know there have been some studies done, heavy metals and how heavy metals get… what happens to them in the marsh. Do they end up in the plants and then eventually going out into the estuaries or are they stored below ground?*
>
> *I: So if you think of the path, thinking of the path that pollutants take when they get to the salt marsh, they either stay there or… where are the potential places it can go? If it comes off the land and gets to the marsh, then where?*
>
> *M: Right. It could either stay there and get buried in the peat or… which some day might still be released, or if it ends up especially in above ground parts of plants it can end up washing out with the tides to the estuaries. Also, you know, if it's in the marsh like that then often things will get passed up the food chain, too, I would assume.*
>
> *Mary, (EO2, Ecologist, p.4)*

In this case the target functions like a sink containing chemicals carried by water. The nutrients are taken up into plants and may be exported to the estuarine food web upon decomposition. The heavy metals may be stored in the peat, until a combination of sea level rise and decomposition releases them, and makes them available for water to move again. The actions of chemicals that bioaccumulate or biomagnify and are later released or cause damage when they reach a critical threshold introduces a temporal dimension to the ways targets are affected by threats.

Not all interviewee discussed ideas of the temporal aspect of threats and the nature of cumulative effects. This represents an area were education could enrich the cultural model of threats by using the underlying structure of the causal sequence and knowledge

about threats changing a target as a basis for introduction of new information about cumulative effects. Knowing the cultural models that people are using to process information about water can be used to identify misconceptions, assess ways to introduce novel information and increase expertise by linking increasingly complex ideas to novice ideas. Applications of cultural models to education strategies will be described in the Discussion section of this report.

Losses Resulting from Threats

The cultural model of threats is linked to the six cultural models of water through this component of the causal sequence. Interviewees reasoning about threats to water was linked to the losses associated with valued attributes and uses of water. High bacteria counts in the estuary cause loss of the ability to harvest clams or swim at the beach. The six cultural models of water capture why and how water is valued, as landscape to recreate in or economic resource supporting harvest of clams. Threats cause loss of water's value. Loss can be felt through the degradation in the quality of a place; the loss of use of a place, or loss of a service associated with naturally functioning ecosystems.

Communication and education aimed at alerting people to threats with impacts on water are most effective when they are linked to loss of the values that people hold for water. Embedding the discussion of and details about threats in the causal sequence of the cultural model of threats makes use of the existing mental pathway people use to think about threats. Using the structure of the causal sequence for education is like sending a signal through an existing cable network, rather than building an entirely new network to deliver a message.

Table 6 compares the cultural models of water to the kinds of losses interviewees described in connection with threats. Knowledge about the importance of water is deeply felt, widely shared and intuitively used when thinking about threats. Water is the basis for life on earth is something that people know. People recognize threats to water and connect the impacts associated with threats to the loss of things they value.

Table 6. Comparison of Cultural Models of Water and Loss Caused by Threats

Cultural Model of Water	Interviewee Reasoning about Loss Caused by Threats
1. Water is the basis for life on earth. Water is the basis of life on earth. Water is essential to humans, animals, plants and all living things. The biological, chemical and physical characteristics of water are the foundation of life from cells, to ecosystems, to global climate. Human health depends upon clean water.	Human health is affected by polluted water. Wildlife is affected by polluted water. Wildlife is affected by loss of habitat. Illness in surfers from Sewage Treatment Plant discharge Loss of quality of life from groundwater pollution, concern for living in a safe/healthy neighborhood.

Cultural Model of Water	Interviewee Reasoning about Loss Caused by Threats
2. Water and land in a natural state, linked as a watershed, function as a water purification and storage system. Water and land are interconnected as part of a natural system. The hydrologic cycle, driven by the sun's energy and the pull of gravity, functions to produce, move, filter, store and clean water as a sustainable and renewable resource. Infiltration, filtering, buffering and other biophysical purification systems work to maintain the cycle. Plants, animals and microorganisms are part of the natural system. Humans benefit from the biofiltration services provided by this natural system	Impervious surfaces cause loss of natural infiltration. Increase runoff accelerates erosion and delivery of pollutants to surface and ground water. Loss of wetland affects nature's ability to purify and store water. Loss of riparian buffers affects nature's ability to purify and store water. Nutrients delivered through atmospheric deposition and runoff accelerate eutrophication and cause red tide
3. Water is a resource for humans to use and manage. Clean water is good business. Clean, abundant water is economically important for residential, commercial, agricultural, municipal and industrial use. Property values, tourism, seafood harvesting and farming are dependent upon clean water. Water is a shared resource	Polluted water: people can't eat freshwater fish or harvest clams. Negative opinion of town's water deters economic development. If you can't drink the water, direct impact on value of that piece of property If you can't swim, it affects value of beach and lake front property. Heavy rains flush pollutants from watershed and result in temporary beach closures. The reputation of a beach can affect the economics of tourism Pollution from old landfills costing community lots of money
4. Water is a Commodity. Drinking water is a public and private commodity. Water is collected from the wild, processed to meet regulatory requirements and sold to meet residential, commercial and industrial needs. Water as a commodity may be sold for profit or as a public utility.	Polluted groundwater, loss of private and public drinking water Water is a finite resource for drinking polluted drinking water sources mean more cost to treat and more byproducts of chemicals used to treat the water to make it drinkable.

Cultural Model of Water	Interviewee Reasoning about Loss Caused by Threats
5. Water is landscape People are drawn to the intrinsic value of water in the landscape as a source of beauty, adventure, peace and serenity. Water landscapes are valued both as backdrops for residential and commercial properties and as sources of more intimate experiences of *re-creation* like fishing, swimming, and boating. Just knowing that a favorite place in nature with clean water *exists* is a source of satisfaction even if the place is not visited.	Boat use is tied to economics there is not the will to limit boats. The majority of the economy is driven by tourism. If you can't swim, it affects value of beach and lake front property. Value of water view.
6. Water is waste Water used as a resource and contaminated as a result of that use becomes waste. Water also becomes waste when it is used as a deliberate or incidental receptacle for pollution. Contaminated water threatens public health and wildlife losses value as a resource. Water that does not filter into the ground can create a safety hazard on paved surfaces.	**Human Actions <u>Turn Water from a Resource into a Threat</u>** If there is a loss of assimilative capacity of the river and discharge not permitted, wastewater treatment facilities must develop alternative approaches, usually at considerable cost. Treating water as a waste or receptacle for waste affects other values of water.

<u>Root Causes of Threats</u>

> *What we're doing out of sheer simplicity and not knowing what else to do with the very limited monies that we have is that we're directing all drainage to from the built up areas near the highway downhill into the marsh and river. So, if that is occurring there should be some thought in the watersheds that all collect into the river, maybe through some elaborate works as we talked about looking further into what Seattle is doing[8]. And concepts of collection and releasing on the outbound tide. Other than that, I don't think we'll ever in my lifetime be able to afford a treatment plant where this stuff would get treated and then released. Jim, Town Manager*

The idea that municipal officials do not act in ways that protect water due to lack of knowledge about threats and their impacts was not supported by these findings. As the quote above illustrates, the economics of replacing existing practices with innovative designs to remove pollution loom as an insurmountable barrier.

[8] Jim and I had discussed Low Impact Development projects being applied in Seattle and showcased on an EPA website.

Interviewees talked about what they perceived as human related root causes of the threats to water. This data emerged from the interviews and was not part of the design of the original project. This aspect of open-ended interviews and grounded theory methodology make them especially valuable for discovering cultural models. An additional benefit for this project and the technology transfer that will follow is the data on root causes that emerged from the interviews. Talk about root causes supplied an *insider's view* of the municipal system of water management in southern Maine. This data is being applied to the technology transfer portion of this project that began in March 2006.

A preliminary summary of that analysis will be presented here. The full analysis of the root causes data with implications for the design of education and outreach programs will be included in the final report for the technology transfer project[9]

Root causes described by interviewees were coded into the five categories below:

- Human Behavior
- Institutional Behavior
- Market Forces
- Temporal Separation of Threat from Losses
- Unintended Consequences

The *Human Behavior* category includes what Naomi Quinn (2005) calls ethnopsychologies. Ethnopsychologies are personal theories that people use to explain human behavior. These personal theories serve us well in most of daily life. They include ideas about what people know, their motivations and their attitudes. Some examples from the interviews include:

- People don't know how their actions affect water.
- Municipal officials don't know how their decisions affect water.
- People don't know that groundwater travels across property lines.

Ethnopsychologies about what people don't know is frequently the basis for education and outreach programs. Municipal officials know a great deal about water management. The findings from this project have been used to adapt existing training strategies so that they are more in alignment with municipal official knowledge. Designing education programs to provide knowledge that an audience already possesses is frustrating for the audience and inefficient for program designers.

Ethnopsychologies about how people learn and connections between learning and behavior are one of the biggest challenges facing education and outreach professionals.

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[9] The technology transfer project **Collaborative Learning Strategies to Overcome Barriers to Science Translation in Coastal Watershed Management** has been funded by CICEET for 2006-2007. Biennial Progress Reports and the Final Report will be posted at http://ciceet.unh.edu/.

Ethnopsychologies can be ineffective program development tools when they are at odds with psychological and educational practices and theories developed through empirical research. Ethnopsychologies about motivation and behavior change can derail elaborately planned and well-funded education projects (MacKenzie-Mohr, 2001.) The technology transfer portion of this project will evaluate root causes of threats to water to identify ethnopsychologies that are barriers to science translation and experiment with ways to replace ethnopsychologies with effective education strategies.

Institutional behavior includes the ways that government, and business practices affect threats. Information on institutional behavior as seen by people inside the institutions is valuable for building a systems understanding of a situation. Some examples of interviewee reasoning about institutional behavior that contributes to water threats are:

- Developers control development.
- The Maine Municipal Association will not allow bills to pass that support current use valuation.
- Municipal government is pro growth, not science based.
- Elected officials can trump planning decisions.
- Conservation Commission members are idealistic and don't understand the realities of code enforcement.

Market forces can be demonstrated using an example from the interviews. Jim, a Town Manager, described a situation in his town where development pressure for land increased in rural areas to the point where homes built near the site of a closed municipal land fill closed in the 1970's were marketable by the 1990's. The plume of contaminated groundwater reached the wells for some of the homes. The decision by the Town Board of Selectmen to purchase the homes to avoid long-term liability from contaminated wells was based in part upon the fact that the market for homes in that area continued to be high. Despite knowledge that the wells were contaminated, people wanted to purchase and own the homes. If the homes stayed in private ownership, the town faced repeated lawsuits stemming from municipal responsibility for the abandoned landfill.

Temporal Separation of Threat from Losses and *Unintended Consequences* are two aspects of root causes that capture systems feedback mechanisms at work in the municipal water management system. Systems thinking and management strategies are central to the Collaborative Learning process being used in the technology transfer part of this project (Senge, 1990; Daniels & Walker, 2001). An example of temporal separation of threats from losses is the slow movement of ground water from a municipal landfill contaminating wells of homes built adjacent to the site twenty years after it was closed. Most threats to water can be framed as unintended consequences. Development that increases impervious surface cover is not *intended* to reduce water quality. Clearing vegetated buffers is not intended to increase erosion.

Temporal separation and *unintended consequences* are manifestations of cause and effect. These two categories of root causes can be addressed by science and education.

Science can discover, describe, and quantify cause and effect linkages. Science can establish links from unintended consequences to causes. Many of these cause and effect linkages relevant to municipal water management have been made by science. The technology transfer project currently underway is focusing on the ways cultural models based education strategies can translate that science into the municipal water management system to address these root causes.

Part III. A Knowledge System for Water Management in Southern Maine

As described in Part I, all interviewees shared a cultural model of the value of water as "the basis for life on earth." People interviewed shared cultural models related to water's economic, public health, ecosystem, and waste dilution values. Part II described how the people interviewed recognized common threats to water and shared a cultural model for the way threats impact the valued attributes of water.

A significant result of this project relevant to science translation and technology transfer was the understanding of the knowledge system for water management in southern Maine. Data from the interviews was used to determine the types of knowledge people used to make decisions about protecting water in southern Maine. The diversity of water protection roles represented by the interviewees proved to be a rich data source. Grounded theory analysis of this data produced a conceptual framework for understanding the knowledge system being used to guide management and policy decisions at the municipal level.

All 20 people interviewed demonstrated expert knowledge related to their roles as scientists, water managers or municipal officials. The distribution of that knowledge can be conceptualized as a system of expertise that includes different ways of knowing about water and water management. Each of the scientists, water managers and municipal officials talked about their perceptions and opinions on the importance of water, threats to water and ways to protect water. They described their individual roles in protecting water as well as their perspective on the larger municipal system of protecting water. Water management expertise among the interviewees drew from seven knowledge domains:

1. Ecological Knowledge: Understanding of the structure and functions of a watershed, the hydrologic cycle, the value of ecosystem services provided by a watershed.
2. Governance Knowledge: Understanding the interrelationships among regulations, government hierarchy, planning documents and ordinances and the governance structures and processes in place to execute them.
3. Land Use Knowledge: Understanding the ways land management and conservation and the design of infrastructure and development can influence water quality and quantity, and the ways that the economic value and ecological value of land can be balanced.
4. Educational Practices Knowledge: Understanding the ways knowledge is generated and transferred within and among each of the other knowledge arenas and evaluating the effectiveness of education and outreach strategies.

5. Science Knowledge: Understanding the factors influencing water quality and quantity for the purpose of documenting conditions, monitoring change, understanding cause and effect relationships and evaluating the effectiveness of management practices and policies.
6. Technology Knowledge: Understanding the use and application of engineering and computer technologies to the protection of water, mitigation of impacts and restoration of lost structure and function in the watershed.
7. Local Knowledge: Understanding the connections between the people and places in the community, including familiarity with town history, values and conflicts.

People use these different knowledge domains to recognize, frame and reason about water and water protection. Expert knowledge within a domain is associated with experience and education. The people interviewed for this project demonstrated levels of expertise and education that may not be reflective of all municipal officials. Effective water management requires input from all domains in this knowledge system and sensitivity to the ways water is valued and threats are perceived within the system. The technology transfer phase of this project will focus on science translation within this knowledge system.

This knowledge system supporting municipal decision-making about water is latent and under appreciated by people working within the system and people working with municipalities from outside the system. One of the most significant contributions of this project to the design the Wells NERR Coastal Training Program was the "discovery" of this system and the realization that is could serve as the foundation for an innovative collaborative approach to environmental management and training. The Technology Transfer and Management Applications section below describes how this knowledge system was used to develop training.

Discussion

Degradation of estuarine water quality associated with non point source pollution has been linked to land use practices in coastal watersheds. In the northeast, home rule governance places responsibility for land use decisions within a complex municipal system that includes staff, elected officials and appointed boards comprised of citizens. Scientific research and technology with applications for the detection, prevention and remediation of water problems must be linked to this municipal system to produce improvements in water quality. Differences in knowledge, values, and problem solving approaches can be barriers to science translation and technology transfer.

This project was designed to examine the role that values and perception play in the production and transmission of knowledge related to water management. Because cultural models play a role in framing and interpreting experience, and guiding action, they were selected as a key to understanding decision-making about water.

The cultural models methodology yielded an added benefit. Analysis produced a conceptual framework for understanding the knowledge system within which water

management is taking place. Understanding the cultural models and the system within which they operate contributes to ecosystem management at the scale where land use is tightly coupled with water quality. This project developed a cultural understanding of municipal water management and used that knowledge to overcome barriers to science translation.

Science Translation Barriers - Moving from Knowledge to Action

Barriers to science translation revealed by this project included conflicting cultural models of the role of science, issues of governance and the design of education programs.

Just tell me what you want me to do!

The statement above captures a busy Town Manager's reaction to the myriad scientific studies his town has received for one very well researched watershed that falls within the National Estuarine Research Reserve. This watershed is part of the NERR national System Wide Monitoring Program (SWMP), was part of a microbial source tracking study, and has been the focus of more than a dozen biophysical research projects. The Town Manager was aware of each project and the recipient of final reports for many of them. A watershed survey and state approved watershed management plan have been prepared for this watershed in accordance with section 319 of the Clean Water act. In the Town Managers opinion, the studies have not helped him decide *what to do* to protect the watershed as development occurs. The quote is a clue to conflicting cultural models of role of science in water management.

Scientists conduct research to answer questions and test hypotheses. Research results describe the status of environmental conditions and can establish cause and effect relationships. Scientists accept uncertainty as part of the scientific enterprise. Scientists are frequently more confident about saying, "We know it's *not* this" than they are saying, "We know it's this." Management prescriptions may be alluded to but are not localized or specific enough for immediate application.

Scientists see connections between changes in land and conditions in water through cultural model #2, *Water and land in a natural state, linked as a watershed, function as a water purification and storage system.* Scientists recognize the ways land use affects nature's ability to provide water to humans. Within the municipal knowledge system, scientists use expert ecological knowledge and science knowledge to identify and characterize the biophysical system in the watershed and to identify and monitor threats and the environmental changes they cause.

Scientists and some water program managers view responsibility for water management as extending beyond the dictates of regulation to include taking actions for which science has provided supporting evidence. Municipalities have the ability to enact local ordinances to protect local resources. Why don't municipal officials act on scientific knowledge or adopt proven technologies?

Municipal officials draw from governance knowledge to manage water within town boundaries. They frame water protection in terms of compliance with regulations, local ordinances and approved plans. Staff, elected officials and volunteer citizen boards frequently defer to outside consultants to assist in interpretation of both science and regulations. Municipal officials actions are driven by compliance with regulations and in respond to citizen concerns. Local knowledge contributes to efficient governance by allowing municipal officials to navigate conflict and controversy. Public works directors and town engineers can infuse technology and land use knowledge into the system.

This project documented ways that ecological knowledge and science knowledge are not being integrated into the municipal knowledge system. Educational strategies for infusing this type of knowledge into the system frequently fail to incorporate an understanding of the ways the system is organized and expert education practices.

Cultural Models of Responsibility for Protecting Water - a Recipe for Conflict

Because of their role as drivers of municipal water management, regulations and the regulatory framework within which they function were key determinants of a cultural model of responsibility for protecting water. Cultural models of responsibility for protecting water align with traditional regulatory approaches to environmental management. A complex regulatory framework applied within the hierarchical structure of federal, state and local governance has produced standardized ways of thinking about responsibility for environmental protection. This is reflective of the traditional *regulator-driven* command and control structure of environmental management that has been the dominant model for the past thirty years (Fiorino, 2001). Conflicts within a cultural model of responsibility for protecting water are manifested through *blaming down* and *trusting up* explained below.

People interviewed for this project identify threats to water and frequently ascribe blame associated with sources and causes of threats. *Blaming down* is the tendency to look down a perceived management or knowledge hierarchy and place blame at levels conceptualized as being *below* - less powerful, less knowledgeable and in some cases less committed to water protection goals. Examples from the findings include state level interviewees describing deficiencies in municipal actions and municipal officials describing deficiencies in the action of town residents. While predominantly described as directed downward, blaming down can be perceived laterally when municipal officials acknowledge institutional practices at the municipal level as sources of threats. Municipal officials "feel" the pressure from regulations coming from "above" at the state level – they are being "hit" with regulations. The state is described in terms that capture the idea that power is being exerted downwards upon the municipalities.

Inherent in the blaming down model is the idea that the lower levels are not as committed or knowledgeable about water protection as levels above. Scientists and water managers may view education programs as solutions to this perceived lack of knowledge-commitment-action to protect water at the municipal level. The data from this project found no lack of commitment to water protection at the municipal level. While there may

be differences in levels of knowledge related to science and technology, that lack of knowledge is not always at the root of environmental protection conflicts. Lack of time and financial resources more often explained as contributing to failures to protect water protection.

A complementary aspect of the *blaming down* concept in the cultural model of responsibility for protecting water is the *trusting up* concept of responsibility, commitment and trust for protecting water. *Trusting up* is based upon the same perception of the regulatory structure for environmental management described above. The *trusting up* is based upon trust that the levels above or experts from outside will take care of water. It involves deferring to the levels above for oversight and management for everything that is not specifically mandated as a municipal responsibility. When asked about wetland protection in town, the chairman of the planning board replied immediately, "That's the state, they take care of that."The *trusting up* cultural model contributes to inaction on the part of the municipal government based upon the perception is that the state is taking care of water.

Conflict arises when the actions to protect water are identified as the need for additional state regulations, stricter local regulations, or more stringent enforcement. Municipal officials site time and resource constraints and concern for economic and property rights issues as barriers to these kinds of actions. Understanding the root causes of inaction and the way institutional barriers between state and local agencies affect actions that to protect water are first steps toward more collaborative approaches to environmental governance (Sabatier et al, 2005).

Watershed Management as Governance - Challenges for Education

Science findings that are codified into regulations, planning documents and ordinances become part of the accepted governance structure of a municipality. Planners, Planning Boards and Code Enforcement Officers base their work around these documents. The decisions and behaviors of developers and landowners are affected by these documents. Most municipalities do not have a mechanism for translating scientific findings directly into actions. The Coastal Training Program of the NERRS, Sea Grant Extension, the National Estuary Program and NEMO programs are all examples of programs that can and do serve the science translation function by moving research findings into a form that matches municipal needs.

To be effective, this translation function must be more than presenting scientific findings in language that can be understood by a layperson. In the case of municipal environmental management, this means determining what the scientific findings *mean* in terms of the decisions and actions that municipal officials make, and then facilitating the codification of those actions into the documents that guide governance such as ordinances, comprehensive plans and regulations. This is a challenging and complex model of a potential role for education and outreach. This entails more than *telling* municipal officials about the results of scientific studies.

An alternative model for science translation professionals is to find ways to link documents like Watershed Management Plans to municipal governance documents and protocols. The Watershed Management Plan is the closest *scientifically generated* planning document to the governance documents that influence municipal decision-making. The watershed management plans produced by the Wells NERR provide such tools. Generated through a participatory process involving citizen volunteers and multiple stakeholders, with oversight by the Maine DEP and Wells NERR scientists, these documents combine the science of monitoring and field research with the social benefits of participation, community involvement and local knowledge.

The "Protecting Our Children's Water" project was designed to implement action items from a Watershed Management Plan through a series of Collaborative Learning workshops involving three municipalities and federal, state and regional stakeholders. The "Protecting Our Children's Water" project was designed to overcome some of the barriers to the movement and application of scientific information caused by conflicting cultural models related to taking action, governance, education and responsibility. An overview of the "Protecting Our Children's Water Project" appears in the Technology Transfer and Management Applications section below.

Technology Transfer and Management Applications

A CICEET funded technology transfer project is currently in progress. This project "Collaborative Learning Strategies to Overcome Barriers to Science Translation in Coastal Watershed Management" applies knowledge of the cultural models of water and the knowledge system for water management in southern Maine to the creation of a Watershed Council and implementation of a regional watershed management plan. The technology transfer phase of this project includes the development of a national Collaborative Learning (Daniels & Walker, 2001) training course for coastal managers and presentations at conferences and meetings.

Funding became available to support technology transfer in March 2006. Because the initial cultural models project was integrated into the Wells NERR CTP, the findings were incorporated into the design of training and outreach beginning in 2005. This section will highlight the ways the results of the project were incorporated into training related to non point source pollution and watershed management.

Introduction

The primary issue facing municipal officials in southern Maine related to non-point source pollution is the conversion of forested and undeveloped land to development. What is critical during the next decade is applying knowledge about low impact development, protection of riparian buffers, preservation of wetlands for infiltration and stormwater management technology and practices that encourage infiltration on site. The science and technology supporting efforts to preserve the *ecological services* provided by

an undeveloped landscape as it is converted to what is considered *economic use* are the focus for science translation and technology transfer (Krum & Feurt, 2002). The importance of translating scientific information about water pollution and watershed management to municipal and local officials emerged as a priority in other NERR sites and is an important management issue for state coastal programs and National Estuary Programs (NEP) (Great Lakes Environmental Finance Center, 2004).

Timely application of scientific research and technological innovations with potential to contribute to improvements in coastal water quality can be blocked when adopters of the information fail to recognize or understand the relevance or benefits. The application phase of this project used knowledge of the cultural models of water and the knowledge system within which they operate to develop an innovative interdisciplinary approach to training and outreach. This approach was designed to overcome cultural barriers to science translation in municipal decision-making about non-point source pollution. This training combined and evaluated methodology and theory concerning the role of cultural models in environmental decision-making (Kempton, et al., 1995) with the process and strategies of Collaborative Learning (Daniels & Walker, 2001) to facilitate science translation and the diffusion of innovative management strategies in coastal watersheds.

Collaborative Learning[10] is a participatory process designed to produce solutions to environmental problems. Collaborative Learning is firmly grounded by an integration of systems theory (Senge, 1990), conflict theory and learning theory. The practice of Collaborative Learning employs a toolkit of techniques to stimulate creative discussion, foster dialogue despite conflict and controversy, and develop group-generated implementation strategies for improving a situation. Collaborative Learning provides a framework for environmental decision making in situations involving diverse stakeholders. It is especially amenable to issues involving conflict and scientific uncertainty. Collaborative Learning aims to facilitate the negotiation of shared meaning among stakeholders with diverse and often conflicting interests. This approach is designed to clarify problem scope and definition, and support the development of strategies that reconcile conflict in order to focus on the design and implementation of actions that improve environmental problems (Daniels & Walker, 2001).

Cultural models research intersects with Collaborative Learning processes in a fundamentally important way. A key premise of Collaborative Learning is that successful learning processes must recognize and accommodate knowledge, value, perception and attitude differences among stakeholders. Acknowledgement of differing knowledge bases and worldviews is one of the primary criteria for effective facilitation of Collaborative Learning experiences (Daniels & Walker, 2001). The cultural models develop through this project provided this rich baseline understanding of stakeholder knowledge, values, perception and attitude differences. The conceptual framework developed for the municipal knowledge system for managing water influenced the design of the Collaborative Learning process.

[10] Collaborative Learning that refers specifically to the approach developed by Daniels and Walker (2001) appears in capital letters to distinguish it from generic references to collaborative learning.

Design of Collaborative Learning Process Using Cultural Models Results

Watershed surveys of non point source pollution document the location, sources and severity of pollution sources in a watershed. Surveys are followed by the development of watershed management plans designed to remediate problems and develop proactive approaches to prevent future pollution. The Wells NERR has conducted watershed surveys and developed watershed management plans for a number of coastal watersheds in southern Maine. The Reserve traditionally had not been involved in the implementation of state approved watershed management plans, even in cases where the Reserve has conducted the watershed survey and written the management plan.

Implementation of a completed watershed management plan was proposed for a test of the cultural models based Collaborative Learning process. The Merriland River, Branch Brook, Little River Watershed Management Plan, mercifully shortened to the MBLR, was completed and approved by Maine Department Of Environmental Protection (MDEP) in November 2004. The MBLR watershed drains three towns, serves as the primary source of public drinking water for five towns, drains portions of federal, state and local conservation lands (including the Wells NERR), and is under strong development pressure.

The watershed management plan proposed the creation of the MBLR Watershed Council to direct the implementation of the plan. Creation of that council was the focus of the Collaborative Learning process during 2005. The composition of the Council and strategies for securing participation were developed with knowledge of the cultural models and the municipal knowledge system related to water management.

The knowledge system used for municipal water management is described on page 45 of this report. Knowledge and expertise can be categorized into seven knowledge domains.

- Ecological Knowledge
- Governance Knowledge
- Land Use Knowledge
- Educational Practices Knowledge
- Science Knowledge
- Technology Knowledge
- Local Knowledge

People interviewed for this project drew from multiple knowledge domains as they talked about the importance of water, threats and ways to protect water. Individual expertise tended to rely on a dominant core knowledge domain with supporting knowledge drawn from other domains. The core knowledge domain was developed through formal and informal education and professional practice.

Examples from the interviews demonstrate the ways knowledge from different domains is applied to decision-making about water. The Project Manager for a development firm had an undergraduate degree in biology, a master degree in planning, and experience as a

Town Planner. He combines knowledge from the Land Use, Ecological and Governance domains when he visits a piece of potentially developable property. He looks at the land and the way the water moves or sits in the landscape and overlays his knowledge of town ordinances and the planning process to evaluate the feasibility of siting a subdivision. Another interviewee with a graduate degree in engineering worked as a Town Engineer. She drew from Technology, Governance and Education domains when she shepherded a landowner through the process of compliance with town ordinances for site design.

Tapping into this kaleidoscope of expertise was one of the goals of the Collaborative Learning process. The municipal officials in this project viewed water management through the lenses of their individual expertise drawing form different domains of knowledge to make decisions. Implementing a watershed management plan at the municipal level would require participation by people involved in a variety of municipal roles.

Water protection is part many jobs. People working in municipal water management operate within distinct action-decision arenas. Planners, Code Enforcement Officers, Planning Board Members, Town Engineers and Public Works Directors focus on different aspect of water management. Action-decision arenas include the specific environmental problems that are recognized, the institutional structure and culture for addressing those problems, existing policies, and socioeconomic conditions (Ostrom, 1999; Sabatier, et al, 2005).

An example of the water action-decision arena for a Public Works Director would include maintaining roads, bridges and municipal infrastructure to functional and safety standards as economically as possible. Oversight by the Town Manager and elected officials and scheduling and management of road crews are part help define this arena. Water and vegetation are viewed as problematic in this arena for safety reasons and maintenance costs. Science and technology with associated water quality benefits that propose changing the way the Public Works Director manages water and vegetation must address concerns for safety and cost and must make their way into the institutional structure that defines the arena. Messages conveying changes to established practices must acknowledge the reality of the target audiences' action-decision arena in order to capture attention and avoid being dismissed as irrelevant.

Collaborative Learning provides a process for bringing the different action-decision arena with connections to water together in ways that tap differing perspectives as a resource for innovation and problem solving. Including different perspectives also supports *systems thinking,* which is one of the cornerstones of Collaborative Learning. The goal of Collaborative Learning is *improvement* in a situation through the concerted actions of disparate stakeholders. New knowledge is introduced to the group for consideration and application in solving group identified problems. This analysis and deliberation of new ideas provides fuel for innovation.

<u>The "Protecting Our Children's Water" project</u>

The "Protecting Our Children's Water" project was designed to implement action items from a Watershed Management Plan through a series of Collaborative Learning workshops involving three municipalities and federal, state and regional stakeholders. The "Protecting Our Children's Water" project was designed to overcome some of the barriers to the movement and application of scientific information caused by conflicting cultural models related to taking action, governance, education and responsibility.

Meeting with Town Managers, Selectmen and Town Councils were scheduled to explain the project, determine municipal needs and secure buy in for the project. A slide show was developed to explain the project. The power point program incorporated three principles of *cultural models based communication* developed by the principle investigator.

1. Analogies were used to build bridges between conflicting cultural models. For example an analogy was made between the role of municipalities in providing services to the community, such as clean safe drinking water, and the ecosystem services of the Branch Brook watershed providing water to the municipality. Both the municipality and the watershed were threatened by the impacts of uncontrolled development and services would increase in cost without proper planning.

2. A second principle of cultural models based communication adjusts for conflicts in temporal aspects of environmental management by proposing tangible environmental management actions that are realizable within a short time frame. Scientists are patient in their research to understand systems and document cause effect relationships. They need more time and more information to increase confidence in their results. Municipal managers don't have the luxury of time. If environmental actions don't yield observable results or can't be completed in a reasonable time, it is hard to keep them as a high priority in the public eye.

3. A final principle is to use local knowledge to situate environmental decision-making in the continuum of local history and familiar places, and to reinforce awareness on the part of municipal officials about the ways their decisions could affect the environment their children will inherit. Each town observing the slide show had recently dealt with the consequences of bad environmental choices made decades ago. In one case a 1950's landfill polluted ground water and necessitated the town buy out of a dozen homes. In another case a former land fill had been declared a superfund site. The proposition "if we knew then, what we know now" captures the idea that with today's knowledge we could have avoided personal and fiscal hardships that came from poor environmental decisions. I make the case in the slide show that we know many things now about protecting water for the future, but that knowledge does not always make its way from the scientists to municipal officials.

One purpose of the "Protecting Our Children's Water" project is to speed the rate of knowledge transfer to towns and involve all of the towns sharing a water source in the process. In every case, elected officials viewing the slide show approved town

participation in the workshops series and appointed municipal staff as delegates to the Watershed Council and the workshop series.

Three Collaborative Learning Workshops based upon Daniels and Walker's (2001) methodology and using the concept of the kaleidoscope of expertise were developed by a research team including Maine NEMO, Maine Sea Grant and Wells NERR. The workshops combine the presentation of information with opportunities for analysis and deliberation of the meanings of the information and relevance of the information to local watershed issues.

The action items from the approved Watershed Management Plan were proposed as a starting point for actions. Workshop participants discussed the action items and selected 4 action items to address during the 4 month project[11]. Participants self separated into smaller workgroups for each action item with a research team member assigned to oversee progress throughout the project.

The final workshop in September will include a focus group evaluation of the project. Individual interviews of participants and grounded theory analysis will also be used to evaluate the project as part of dissertation research.

Presentations to elected officials in the three towns presented the accomplishments of the watershed council process and solicited approval from elected officials for continued commitment to participate. Approval was unanimous from all town.The watershed council met in Februry 2006 to report on progress set the agenda for action items for the coming year.

The watershed council is still in its infancy, however, feedback has been positive. One participant captured the mood of the group after the first meeting by saying, "I've never been to a meeting where we actually did something as a result of the planning." Working relationships have been forged that didn't exist before, and the research team driving the process has been enthusiastic about the potential for Collaborative Learning to overcome barriers to action.

The research team meets every month to discuss progress on the action items and reactions to this approach to watershed management. While these ideas and education practices are not completely new, they are new to Maine and new to the NERRS system. This project served a vital role as a demonstration projects that moves ideas from the abstract world of theory to a place where people can see ideas in action.

<u>Summary of Lessons Learned and Guidelines for Using Collaborative Learning Based upon Cultural Models</u>:

1. The cultural models revealed strongly held values related to clean water, across a wide spectrum of stakeholders. All shared the common goal of protecting and

[11] These action items appear in Appendix III.

improving water quality. The Collaborative Learning process was founded upon these shared perceptions and goals.

2. The cultural models revealed conflicts in the way science approaches water protection and the way municipal officials approach water protection. Action to improve water in spite of scientific uncertainty was key to municipal participation.
3. Incorrect perceptions that environmental management was not a priority for municipal officials resulted in information delivery approaches designed to "teach them what we know so they will act to protect water." This apporach failed to recognize the considerable expertise actively being applied to protect water at the municipal level.
4. The cultural models revealed sources of conflict in water protection related to property rights and economic development viewed as vital for the tax base of municipalities. These ideas collided with the concept of water and land as an integrated system through which the water cycle functions to purify and store water for human use. One task for the Collaborative Learning workshops was to make these dualing concepts explicit and to challenge the group to design watershed protection strategies that would work through this conflict. Principles of Low Impact Development have been proposed as one solution.
5. Environmental management at the municipal level is as aspect of governance. The culture of this governance system is fundamentally distinct from the culture of the scientific system that produced the Watershed Management Plan. By combining the systems understanding of cultural models research with the process of Collaborative Learning those two cultures can be bridged.

Dissemination

Conferences[12]

The Coastal Society in Newport, RI, May, 2004.
Paper presented, "Science translation for non-point source pollution control - A cultural models approach with municipal officials" Audience: 20 coastal management professionals

The International Living Knowledge Conference in Seville, Spain, February 2005.
Paper presented, "The Wells National Estuarine Research Reserve, USA - A Model for Collaborative Community Conservation"
Audience: 50 international scientists and water program managers

Society for Applied Anthropology Annual Meeting Santa Fe, NM April 2005.
Paper presented "Through the Looking Glass, Using Cultural Models to Understand Barriers to Science Translation in Coastal Watershed Management"
Audience: 30, including coastal managers from state, local and federal agencies

[12] Every abstract of this research that has been submitted to a conference has been accepted for presentation.

Coastal Zone 05 New Orleans, LA, July 2005
Paper presented "Understanding Barriers to Science Translation in Coastal Watershed Management"
Audience: 30 including coastal managers and graduate students

Estuarine Research Federation Annual Meeting Norfolk, VA October 2005
Paper presented "Understanding Barriers to Science Translation in Coastal Watershed Management"
Audience: 60 including scientists, coastal managers and students

Upcoming Conferences:
The Coastal Society St Petersburg, FL May 2006
Presentation scheduled "Protecting Our Children's Water" - Using Collaborative Learning to Bridge Disciplinary, Institutional and Perceptual Barriers to Improve Coastal Watershed Management.

The International Symposium for Society and Natural Resources Vancouver, BC June 2006
Presentation scheduled "Protecting Our Children's Water" - Using Collaborative Learning to Bridge Disciplinary, Institutional and Perceptual Barriers to Improve Coastal Watershed Management.

Training and Workshops

CTP Coordinators, NERRS Educators Meeting Apalachicola NERR, February 2003
Presentation - Cultural models as and Education Tool
Audience: 20 CTP Coordinators, ERD staff

CTP Coordinators, NERRS Educators Meeting Padilla Bay NERR, February 2004.
Presentation - Update on Cultural Models Project
Audience: 20 CTP Coordinators, ERD staff

NERRS Annual Meeting Wells NERR, October 2004.
Half day training session introducing the concept of Collaborative Learning and Social Science Methodologies for Coastal Management
Audience: 50 NERRS staff and coastal program managers

NERRS Annual Meeting Rookery Bay NERR, December 2005
Presentation - "Overview of Protecting Our Children's Water"
Audience: 20 CTP Coordinators, ERD staff

NERRS Educators Meeting Feb 06 Delaware NERR, February 2006
Presentation - Adaptive Management the Role of CTP
Audience: 20 CTP Coordinators, ERD staff

Wells NERR CTP and Staff July 27, 2005 Wells, MA
Presentation "Understanding Barriers to Science Translation in Coastal Watershed Management"
Audience: 17 staff

Training for staff of Wells NERR, Sea Grant, Maine Nonpoint Education for Municipal Officials (NEMO) in Collaborative Learning design as part of the "Protecting Our Children's Water" workshop series. Spring - Summer 2005

Collaborative Learning Workshops 2005 - 2006:
A series of Collaborative Learning Workshops was developed based upon findings from this project. These workshops provided an opportunity to bring federal, state and municipal officials involved with water management together to implement action items associated with a state approved watershed management plan.

Protecting Our Children's Water 2005 - 2025
A Workshop Series Implementing the Branch Brook, Merriland River and Little River Watershed Management Plan
A Collaborative Project in Wells, Sanford and Kennebunk, Maine

May 17	Present Watershed Plan and Selection of Action Items	(22 participants)
June 9	Land Protection Teleconference	(5 participants)
June 22	Tour and Meeting at UNH Stormwater Research Center	(20 participants)
July 12	Tour of Sanford Airport	(24 particpants)
September 28	Progress Report on Action Items, Evaluate the council	(22 participants)

2006

February 1	Action Item Planning for 2006	(20 participants)

Manuals, Protocols

The cultural models primer for Coastal Training Program Coordinators in National Estuarine Research Reserves, "Cultural Models - a Tool for Enhancing Communication and Collaboration in Coastal Resources Management" prepared for this project summarizes cultural models literature relevant to coastal management. This primer provides an orientation to cultural models research methodology, theory and contributions to coastal management, specifically in the design of education and outreach strategies. A copy of the primer is attached as Appendix III.

Over 100 distributed at conferences listed above

Outreach

Featured article Spring 2005 - Non point Source Pollution Newsletter produced by Maine Department of Environmental Protection

Featured article Winter 2006 The Watermark Newsletter of Laudholm Trust and Wells NERR

Local Media Coverage of Protecting Our Children's Water Project

Contact with End Users:

End users for this methodology include coastal managers, municipal officials, science communicators, education and outreach specialists working at the interface between science and policy. The nature of the work of these end users requires interaction across disciplines, institutional scales (federal, state, local).

The end users of this cultural models methodology for outreach, training and education that improves water and watershed management are active participants in the design, implementation and evaluation of the Protecting Our Children's Water workshop series described above.

During 2005, the Principal Investigator spent 100 hours in meetings and presentations to municipal officials involved with water management in southern Maine.

Appendix I: Interviewees and Their Roles

#	Code Name	Role
MO-01	Bart	Town Manager
MO-02	Bernice	Town Planner
MO-03	Ward	Town Manager
MO-04	Lewis	Manager Wastewater Treatment Plant
MO-05	Spencer	Conservation Commissioner
MO-06	Jim	Town Manager
MO-07	Les	Highway Department Manager
MO-08	Ann	Citizen Member of Planning Board
MO-09	George	Project Manager for Developer
MO-10	Curt	Elected to Town Council
MO-11	Lee	Town Planner
MO-12	Van	Chairman Planning Board
MO-13	Ben	Technical Services Director Water District
MO-14	Dan	Code Enforcement Officer
MO-15	Cherie	Town Engineer
MO-16	Mack	Coordinator local office of Senator
E-01	Cathy	Coordinator State Water Education Program
E-02	Mary	Coastal Ecologist, University Professor PhD
E-03	Gary	State DEP Regulator
E-04	Mike	Watershed Educator and Training Coordinator
E-05	Jack	State Coordinator NPS Water Program

Appendix II:
Demographic Profiles of Towns & Municipal Officials Interviewed

Town 1	**Town 2**	**Town 3**
Population 22,000 Median Income: $37k Elected Town Council form of Government	Population 12,000 Median Income: $24k Selectmen form of Government	Population 13,000 Median Income: $34k Selectmen form of Government
Interviewees	**Interviewees**	**Interviewees**
Town Manager Town Planner Chair Planning Board Planning Engineer	Town Manager Town Planner Code Enforcement Officer Wastewater Treatment Plant Manager Technical Services Director Water District (regional)	Town Manager Planning Board Member Highway Department Supervisor Conservation Commissioner/Farmer/ Former Selectperson
Interviewee below works in Town # 1, lives in Town # 2	**Interviewee below works regionally, lives and serves on Municipal Boards in Town #2**	
Legislative Aid to Senator from Maine/ Former State Legislator	*Project Manager for Developer*	

Appendix III Interview Guide

Cultural Model Non-point source pollution- Interview Guide

Introduction:
In the broadest sense,
I am trying to learn what people think about water quality.
Why is water quality important? Importance
What are threats to water quality? Threats
How can water quality be protected? Protection

I. Why is water quality important?

II. What are threats to water quality?

Sources

Tell me about that (storm water, lawn chemicals, agriculture)

If mention NPS:

Suppose you are trying to describe NPS pollution, how would you describe it?
(learn from the person)

If not mention NPS:
Now, I'm going to ask you about non-point source pollution.
Suppose you are trying to describe NPS pollution, how would you describe it?

III. How can water be protected?

How do you think water can be protected?

IV. Municipal Officials Role in protecting Water

Do you think the decisions of municipal officials affect water quality?
Which municipal officials?
What you think municipal officials need to know about protecting water quality?
What kinds of information about non-point source pollution do you communicate to municipal officials?
How do you provide that information?
What kind of information about non-point source pollution do municipal officials need to report to you?
How do they provide that information to you?
What kind of information about nps pollution do municipal officials ask for?
What can be done at the municipal level to reduce nps pollution?

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